THE UNIVERSITY OF ALBERTA

THE RELATION OF SEED SIZE TO LOOSE SMUT INFECTION AND YIELD IN BARLEY

A THESIS

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ABSTRACT

The incidence of loose smut (*Ustilago nuda* (Jens.) Rostr.) infection, as influenced by different sizes of seed from different positions on the spike, and the effect of seed size on some characters related to yield were studied in two main experiments using several barley varieties. These varieties were represented by large, medium, small and bulk seed fractions and sown, in part, at different rates.

The results in the first part of the study showed that loose smut infection is intimately related to seed size. Under natural conditions the most important relation was that small-sized seeds from lateral florets tend to carry more smut infection than larger seeds from central florets.

The results of the second part may be summarized as follows: (1) Number of seedlings per unit area did not show significant improvement as the size of seed sown was increased, the rate of seeding being the main determinant of number of seedlings. (2) Number of culms per unit area tended to increase with increasing the size of seed sown, indicating that plants from large seeds produce larger numbers of culms than plants from small seeds. A progressive increase in the number of culms also resulted from increases in rate of seeding. (3) Larger numbers of smutted heads were found in plants derived from small seeds. Rate of seeding had no effect on percentage of smutted heads. (4) The 1000-kernel weight in grams in the resulting plant was influenced to some extent by the size of seed sown, but the trend was not consistent, the weight

per 1000 kernels being decreased as rate of seeding was increased. (5) A direct relation was found to exist between the size of seed sown and resulting yield. Yield of grain tended to be greater as larger seeds were used. Yield in grams per plot was also significantly modified by the rate of seeding, indicating small further increase from the heavy rate over medium (optimum) rate.

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I. INTRODUCTION

Although seed size is controlled primarily by hereditary factors, its actual expression is attributable to the interaction between these factors and the environmental conditions under which plants grow. Besides the obvious effects of weather and soil conditions, seed size may be influenced by the position of the flower on the inflorescence as well as by the position of the inflorescence on the plant.

Several workers have worked out correlations between seed size and the position of the flower on the inflorescence and of the inflorescence on the plant. Many years ago Noble, cited by Kidd and West (20), showed that in the case of barley, variation in the seed size is correlated with its position on the spike. Kidd and West (20) reported that the size of seed appears to be almost entirely controlled by its relative position on the spike. The largest grains, in the case of barley, are situated at the middle or somewhat below the middle of the spike. A positive correlation was also found to exist between the size of the seed and the vigour of the resulting plant and thus yield of grain.

It has also been reported that the size of the seed has some relation with the incidence of loose smut in barley. Small and medium sized seeds from lateral florets were found to be more highly infected than larger seeds from central florets (23, 34, 35).

The present investigation was undertaken with the following objectives: (a) a detailed study on the differential incidence of loose smut as affected by seed size dependent on the position of the floret in the different parts of the spike, and (b) a study of the effects of progenetorial seed size on resulting yield.

The data presented in this paper are the result of a two-year field and greenhouse study made during 1959 and 1960, and are presented in two main parts.

i. The incidence of loose smut infection and its relation to the size of the seed borne on different parts of the spike. Development of loose smut was observed on plants grown from large, medium and small seeds derived from central and lateral florets on the lower, middle and upper parts of the spikes obtained

   (a) from artificial inoculation

   (b) under natural conditions

ii The effect of seed size on some characters related to yield from

   (a) infected and non-infected* large, medium, small and bulk seeds;

   (b) non-inoculated large, medium, small and bulk seeds; and

   (c) non-inoculated large, medium and small seeds sown at different rates.

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* The terms "infected" and "non-infected" have been used in this study to describe artificially inoculated and non-inoculated seeds, respectively.

II. REVIEW OF LITERATURE

The presence of the loose smut fungus (Ustilago nuda (Jens.) Rostr.) in the embryo of barley seed results in reduced stand and yield. Also, some studies have shown that loose-smut infection results in a slight reduction in kernel size.

Taylor (34) observed in wheat that an average of 67.3 loose-smutted heads were present in each 96th acre plot sown with small seeds as compared with an average of 12.7 heads infected with loose smut in each plot sown with large seed. A possible explanation of the larger percentages of loose smut in the plots from small seeds is that the presence of loose-smut organism, which enters at the flowering time, may check the development of the endosperm of the wheat kernel, causing a slight reduction in kernel size and weight.

On the other hand, some studies in barley have indicated that small and medium sized seeds from lateral florets carried more smut infection than the larger seeds from central florets.

The barley variety, Nakano Wase was tested in different places and years by Taylor and Harlan (35) by dividing it into two samples. One consisted of central kernels, the other of lateral kernels from the same spike. The results showed that the incidence of smut was much greater in plants from lateral kernels than in those from central kernels. From a continuation of the above experiment with two hybrid varieties which derived from Nakano Wase, they obtained an average of 1.8, 5.4 and 12.8 per cent infection in plants from large, medium and small seeds, respectively. They

concluded that the lateral flowers mature later than the central ones, which allows greater opportunity for infection in the lateral flowers.

Similar results have been obtained from the composite work carried out at Saskatoon, Edmonton and Lacombe by McFadden et al. (23). In 1955 samples of five barley varieties were separated into large, medium and small seed lots and each lot was subjected to the embryo test for determination of infection at Saskatoon. The results showed an average of 3.2, 8.7 and 13.5 per cent infection for large, medium and small seeds, respectively. These results were in close agreement with the results of the growth test conducted at Lacombe. The results from the field test conducted at Edmonton showed lower percentage of smut in all seed classes but the relation between the classes agreed with the results from the embryo test. The incidence of loose smut in Husky and Gateway grown in the field at Lacombe in 1958 and 1959 averaged 3.02, 0.41, 2.86 and 5.55 per cent in plants from bulk, large, medium and small seeds for Husky and 0.56, 0.22, 0.59 and 1.55 per cent for Gateway, respectively. The conclusion from all experiments was that small and medium sized seeds carried more loose smut than large seeds.

On the other hand, the work carried out at the Kiel-Kitzeberg branch of the German Biological Institute by Niemann (25) indicate that none of the four methods of grading and selecting seed samples proposed by various workers for the control of loose smut of barley and wheat (involving separation by size, specific weight, single-seed weight and winnowing) resulted in a consistent reduction of infection.

In infection tests made by Milan (24) the percentage of infected ears from wheat sown thinly was 85, while that of the plants sown thickly was 95.4. Another wheat variety sown thinly gave 60.5 per cent infected ears. When the rate of sowing was increased five times it gave 80.5 per cent, and when it was increased 10 times it gave 86 per cent infected ears. He concluded that rate of sowing exercised virtually no effect on the percentage of the plants that became infected, but very greatly affected the percentage of the heads that became diseased.

The yield losses of grain caused by loose smut in two wheat varieties has been studied by Compton and Coldwell (7). They found that the reduction in yield of wheat, resulting from loose smut, would approximate the percentage of loose smut infection. This result is similar to that of Semeniuk and Ross (31), who found the percentage yield losses in spring barley to be approximately as great as percentage of loose smut infection.

Effect of seed size on the establishment of plants has been studied by many workers. Some original data and a review of the literature dealing with the subject of physiologic predeterminations have been presented by Kidd and West (20). They concluded, largely on the basis of the literature, that the balance of evidence is in favour of the conclusion that larger seeds give rise to more vigorous plants and better yield, and that the environment under which seed is produced may have a marked influence on plant development. Their evidence consists chiefly of the effects of size of seed.

Kiesselbach and Helm (21) sowed hand-selected large and small seeds, alone and in competition with each other. Plants grown from small seeds yielded 11 per cent less than those from large when there was no competition between plants grown from seeds of the two sizes. The yield was 24 per cent less when plants from the two seed categories were grown in competition with one another. In a two-year trial of unselected and hand-selected large and small seeds of two winter wheat varieties, the yield from the large seed was 2.3 per cent greater than that from the unselected seed and 5.4 per cent greater than from the small seed. In a similar trial with two varieties of spring wheat the yield of grain from the large seed was 11.8 per cent greater than that of the unselected seed and 19.5 per cent greater than the yield from the small seed. The conclusion regarding size of seed was that, when seeds are sown in equal numbers at a rate optimum for the large seed, a lower yield is obtained from the small than from the large seed. As an average for all investigations this difference amounts to 12 per cent. When sown in equal weights at a rate optimum for the large seed, all three grades - large, small, unselected - yielded equally.

Zavitz, cited by Arny and Garber (2), carried out an experiment for several years with various field crops, testing yield resulting from the use of large, medium and small seeds, equal numbers of seeds being sown on equal areas in each case. Averaging the results per acre for the whole period he found a marked superiority in favour of the large grains. In barley hand-selected large plump seed yielded 10.6 bushels per acre more than small plump seed of the same variety.

Arny and Garber (2) made correlation studies in wheat involving (a) the degree of relation between weight of seed and characters of the resultant plants and (b) the degree of interrelation between characters of the resultant plants. The seeds for sowing were selected by hand and weighed, then arranged in classes according to weights. From this study conclusive evidence was obtained that, under a given set of conditions, environment reduced radically or entirely the correlation between weight of seed sown and plant characters including yield. In the study of the interrelation of plant characters, a substantial and fairly consistent positive correlation was found between yield and kernel weight, and a somewhat higher correlation between yield and number of culms. The correlation between weight of seed sown and resultant plant characters at maturity was not high in any instance and may be so modified by environmental conditions that the relation may be slightly or entirely obliterated.

Winifred (37), working on effect of weight of seed sown upon the resulting crops, found that the result with barley grown under controlled conditions from seeds of different weights supported the view that there is an advantage generally in spring cereals from sowing heavy, well-filled seeds instead of corresponding numbers of light seeds even though equally well-filled. There was a steady and considerable rise in the dry weight of the plants as the initial weight of the seed increased.

According to Bonnett and Woodworth (4) plants from large seed within the same variety produce a larger number tillers than

plants from small seed. With the barley varieties used in this study, the results with respect to effect of difference in the weight of seed upon head production does not agree with those of Kiesselbach and Helm.

In a recent study by Kaufmann and McFadden (19) the competitive effect on yield of plants grown from large and small seeds was demonstrated in both greenhouse and field tests. Plants from small seeds yielded approximately 77 per cent of those grown from large seeds in greenhouse, and 57 per cent in the field with inter-plant competition; with inter-row competition the percentages were 70 and 54 per cent, respectively; and with no competition they were 89 and 83 per cent respectively. Superior production resulted mainly from a greater number of heads on plants grown from large seeds.

Kaufmann (18) studying the influence of the seed size on seedling development and on features of the mature plant in barley found highly significant differences in growth for both roots and top, and in tiller production between plants grown from large and small seeds.

Many investigations have been conducted by numerous workers to determine the optimum quantity of seed required for a given area of land. The optimum rate of seeding for any crop varies both with the characteristics of the variety and the environment in which it is grown.

Grantham (10) carried out an experiment on a large number of varieties of wheat. The seeds were sown at three different rates. The comparison of the yield of grain of 25 heads from plots from each of the different rates of seeding showed some marked variations. The reduction in yield from thin seeding as compared with thick seeding was 5.8 grams or a decrease in yield of 37 per cent. The reduction from medium seeding as compared with thick seeding was 2.9 grams or 23 per cent decrease.

Atkinson (3) sowed spring wheat, oats and barley at the rate of 2, 4, 6, 8, 10, 12, 14 and 16 pecks per acre each spring for eight years and found that from the point of view of yield the heavier rate of seeding gave the best returns. With barley the highest average yield was from the 16-peck seeding.

Sprague and Farris (32) made a study to determine the effect of seed spacing on the development and final yield of barley. The standard rate of seeding was 10 pecks to the acre which was an optimum quantity of seed for the region in which it was sown. The four variable rates were 6, 9, 11 and 14 pecks of seed per acre. He found a clear relation between the rate of seeding and the percentage of infertility. The total number of fertile culms per foot section was obviously greater for the heavier rate of seeding but the number of fertile culms per plant was inversely correlated with population density. The average grain weight was not significantly modified by the rate of seeding. In spite of a progressive increase in rate of seeding, there was no increase in grain yield with more than 11 pecks of seed. The conclusion drawn by Sprague

and Farris was that no advantage was derived from the sowing of more than 11 pecks of seed under the conditions studied. With a more favourable growing season, the inclusion of the 14-peck rate might have increased yields appreciably.

The data obtained by Godel (9) gathered in the course of a rate of seeding experiment in Saskatchewan, showed that heavy seeding on weedy land reduces the size of plants somewhat, but not as much as on clean land. The yield of grain, on the other hand, was usually increased by a few bushels per acre. The effect of rate of seeding depends on the variety sown, the condition of the land at seeding, the size of kernels, and the degree of weed infestation of field, etc.

Hutchison (12) compared various rates of seeding for cereals and found the best average yield of grain resulted from the rate of 96 pounds of seed per acre. The rate of seeding of 61 to 129 pounds per acre resulted in fairly uniform average yield of grain.

Thayer and Rather (36) working with certain barley varieties determined the differential response to different rates of seeding. As the rate of seeding was increased, the number of plants per unit area increased, but tillering, length of culm, length of head and number of kernels decreased.

The results reported by Robertson _et al_. (29) showed that there were significant differences in yield within rates and dates of seeding, and that rates within dates tend to hold the same relative position. Rates within years also show a tendency to remain constant.

The series of investigations on the cultural studies with barley were conducted at four stations in Manitoba by Olson et al. (26). Results of experiments involving fertilizer treatment and rates of seeding, using three barley varieties, showed that the rate of 1-3/4 bushels per acre gave a substantial increase in yield over the one bushel rate. Only a small further increase resulted from the 2-1/2 bushel rate. In general the order of yield under different rates of seeding was consistent at all dates. There was no interaction between rate of seeding and fertilizer treatment.

Machacek et al. (22) working with wheat, oats and barley found, in general, that the yield per head decreased as the rate of seeding increased, while yield of grain per plot for all three crops tended to increase as the seeding rate was increased.

Woodward (38) conducted rate and date of seeding experiments on irrigated land. Wheat, oats and barley were sown on three dates at various rates per acre during three years at two stations. Rates of seeding gave only minor differences in yield averaged over three years. Velvon barley yielded consistently well at higher rates ranging up to 140 pounds per acre.

Glynne and Slope (8) made a two-year experiment with spring barley, studying lodging and yield in relation to seeding rate and nitrogen fertilizer applications. They concluded that seeding rate was directly related to degree of lodging of spring-sown barley. The effect of seed rate on yield of grain was unexpectedly small. The difference between rate 1 and rate 2 was greater than between rate 2 and rate 3 over all rates of nitrogen.

Rennie (28) working on seeding rates and rates of nitrogen application for spring barley found that a seeding rate higher than 100 pounds per acre did not result in any increase in yield. Higher seeding rates also reduced the vigour of the individual plant, and produced less tillers per plant and lighter seed weights.

Jackson and Page (13) studying seeding rates for spring barley and winter wheat in nine trials found very small increase in yield with increasing seeding rate over the range 100 to 250 pounds per acre.

Pendleton and Dungan (27) conducted seven winter wheat trials over a three-year period to study the effect of seeding rate and rate of nitrogen application. They found that varieties responded differently both to seeding rates and to rates of nitrogen application. In a comparison based on net yield, the 6-peck per acre rate gave the highest grain yield and yield rankings were unchanged at the different rates of nitrogen application.

In a more recent experiment, the response of two wheat, three oats and three barley varieties to six seeding rates was studied by Guitard _et al_. (11). For all crops, it was found that increase in seeding rate caused a linear increase in the number of plants per acre and a curvilinear decrease in the number of fertile heads per plant. There were also associated reductions in number of kernels per head and 1000-kernel weight. Concerning the yield of barley they found yield increases associated with seeding rates of up to 3.5 bushels per acre at one station, however, at two other stations yield depressions were caused by above-optimum seeding rates for barley.

III. MATERIALS AND METHODS OF PROCEDURE

A. Sources and preparations of seeds

The barley varieties used in the first part (Experiments i, a, b) to study the incidence of loose smut (*Ustilago nuda* (Jens.) Rostr.) infection and its relation to the size of the seed borne on different parts of the spike were Titan, Newal, Gateway, York, Parkland, Montcalm, Wolfe, Compana and Herta.

In the second part (Experiments ii, a, b, c) to study the effect of seed size on some characters related to yield were:

(a) infected and non-infected large, medium, small and bulk seeds from Parkland, Gateway, Montcalm, Wolfe, Compana and Herta

(b) non-inoculated large, medium, small and bulk seeds from Gateway, Husky, Wolfe, Parkland, Olli, Pirkka, O.A.C. 21, Nord and Fort

(c) non-inoculated large, medium and small seeds sown at different rates were from Gateway, Husky and Wolfe.

Among these varieties only Compana and Herta were two-rowed barley (*Hordeum distichum* L.), the others were six-rowed barley (*Hordeum vulgare* L.).

The supply of the non-infected seeds of these varieties was obtained from Lacombe Experimental Farm in 1959. Smut infected seeds of varieties used in Experiment ii, a were obtained from the Research Station, Saskatoon, Saskatchewan. They were generally supposed to have from 1.1 to 2.1 per cent infection according to

the embryo tests. For the preliminary study on the incidence of loose smut, artificially infected seeds of Titan and Newal barley were obtained from the University of Alberta Parkland Farm. The head samples of Titan were artificially inoculated in 1959, but the Newal sample was a remnant of the stock which had been prepared by Semeniuk and Ross (31) in 1938 and 1939.

The incidence of loose smut in different parts of the spike was studied under field and greenhouse conditions. Seed from heads which were artificially inoculated or exposed to natural infection were divided into six parts on the following basis:

	1000-kernel weight in grams
1. lower 1/3 of spike central kernels	40.50
2. lower 1/3 of spike lateral kernels	30.46
3. middle 1/3 of spike central kernels	43.81
4. middle 1/3 of spike lateral kernels	34.43
5. upper 1/3 of spike central kernels	36.31
6. upper 1/3 of spike lateral kernels	28.15

Three or six kernels, depending upon the length of the spike, between the middle and lower, and the middle and upper parts of the spike were discarded. The average 1000-kernel weight of fractions, over all varieties used in this study, are given above for each category.

The method of obtaining seed categories for inoculated and non-inoculated samples of seven varieties used in the test of the effect of seed size on some characters related to yield (ii, a) may be summarized as follows:

Varieties and categories	Sieves
Parkland I, II, Herta	
Large	over 7/64" x 3/4" slotted sieve
Medium	pass through 7/64" x 3/4" slotted and over 6/64" x 3/4" slotted and 9/64 round sieves
Small	pass through 6/64" x 3/4" slotted and 9/64 round sieves
Gateway, Wolfe, Montcalm	
Large	over 7/64" x 3/4" slotted sieve
Medium	pass through 7/64" x 3/4" and over 6/64" x 3/4" slotted sieves
Small	pass through 6/64" x 3/4" slotted sieve
Compana	
Large	over 7/64" x 3/4" slotted sieve
Medium	pass through 7/64" x 3/4" and over 6/64" x 3/64" slotted and 10/64 round sieves
Small	pass through 6/64" x 3/4" slotted and 10/64 round sieves

The method of obtaining seed categories for the samples of varieties used in the study of the effect of seed size on yield as influenced by rates of seeding (ii, c) is summarized as follows:

1959

Varieties and categories	Sieves
Gateway, Wolfe, Nord, Fort	
Large	over 7/64" x 3/4" slotted sieve
Medium	pass through 7/64" x 3/4" and over 6/64" x 3/4" slotted sieves
Small	pass through 6/64" x 3/4" slotted sieve
Husky, Parkland, Pirkka, O.A.C. 21	
Large	over 7/64" x 3/4"
Medium	pass through 7/64" x 3/4" and over 6/64" x 3/4" slotted, 9/64 round sieves
Small	pass through 6/64" x 3/4" slotted and 9/64 round sieves
Olli	
Large	over 10/64 round sieve
Medium	pass through 10/64 round and over 7 triangular sieves
Small	pass through 7 triangular sieves

1960

Gateway

Large	over 6/64" x 3/4"
Medium	pass through 6/64" x 3/4" and over $5\frac{1}{2}$/64" x 3/4"
Small	pass through $5\frac{1}{2}$/64" x 3/4"

Husky, Fort

Large	over 7/64" x 3/4"
Medium	pass through 7/64" x 3/4" and over 6/64" x 3/4"
Small	pass through 6/64" x 3/4"

Parkland, Wolfe

Large	over 7/64" x 3/4"
Medium	over $5\frac{1}{2}$/64" x 3/4"
Small	over 5/64" x 3/4"

O.A.C. 21, Nord, Olli, Pirkka

Large	over 7/64" x 3/4"
Medium	over $5\frac{1}{2}$/64" x 3/4"
Small	pass through 5/64" x 3/4"

Only slotted sieves were used for the separation of seeds in 1960.

Each seed size category for each variety was determined on the basis of the average weight of four 100-kernel samples. The 1000-kernel weight of seed categories for each variety are given in Tables 1 and 2.

The mean weight of seed categories indicate a sufficient distinction between size classes to provide a good differential for experimental studies.

Table I. Seed-size data for varieties used in the study of the effect of seed size on some characters related to yield from Experiment ii, a

Varieties	Seed size	1000-kernel weight (in grams) Infected	Non-infected
Parkland I	Large	44.97	48.97
	Medium	38.52	39.67
	Small	32.20	32.22
	Bulk	36.62	40.12
Parkland II	Large	41.80	48.97
	Medium	38.42	39.67
	Small	29.82	32.22
	Bulk	38.40	40.12
Montcalm	Large	41.87	48.32
	Medium	37.32	40.62
	Small	26.52	29.32
	Bulk	34.12	37.95
Gateway	Large	40.25	42.70
	Medium	36.97	34.67
	Small	31.67	27.45
	Bulk	36.07	34.25
Wolfe	Large	43.57	47.50
	Medium	38.30	37.12
	Small	30.85	27.32
	Bulk	38.10	36.85
Compana	Large	60.97	61.22
	Medium	55.35	55.27
	Small	50.07	36.80
	Bulk	55.72	53.47
Herta	Large	46.60	36.75
	Medium	42.07	33.42
	Small	32.40	28.17
	Bulk	41.50	33.40

Table 2. Seed-size data for varieties used in the study of the effect of seed size on some characters related to yield from Experiments ii, b and c

Varieties	Seed size	1000-kernel weight (in grams) 1959	1960	Average
Parkland	Large	50.00	49.47	49.74
	Medium	40.27	29.37	34.82
	Small	32.75	21.00	27.88
	Bulk	39.57	37.17	38.37
Olli	Large	36.30	40.45	38.38
	Medium	29.42	30.40	29.91
	Small	22.72	17.85	20.29
	Bulk	31.50	31.32	31.41
Pirkka	Large	46.75	46.02	46.39
	Medium	41.07	30.50	35.79
	Small	32.47	17.70	25.09
	Bulk	40.25	33.82	37.04
O.A.C. 21	Large	46.52	30.55	38.54
	Medium	37.05	31.77	34.41
	Small	28.55	19.97	24.26
	Bulk	37.52	37.25	37.39
Nord	Large	46.82	52.15	49.49
	Medium	40.40	32.12	36.26
	Small	29.52	24.05	26.79
	Bulk	40.55	39.90	40.23
Fort	Large	42.85	45.77	44.31
	Medium	35.70	37.55	36.63
	Small	24.62	25.72	25.17
	Bulk	34.37	37.67	36.02
Gateway	Large	44.40	36.85	40.63
	Medium	36.07	27.65	31.86
	Small	27.32	20.37	23.84
	Bulk	32.35	31.02	31.69
Husky	Large	50.90	49.35	50.13
	Medium	40.47	38.35	39.41
	Small	31.02	25.12	28.07
	Bulk	38.37	38.07	38.22
Wolfe	Large	49.12	46.95	48.04
	Medium	38.60	32.35	35.48
	Small	28.85	22.92	25.89
	Bulk	37.22	34.97	36.09

B. Experimental methods

I. Experimental design

Four experiments designed to study:

(a) ten barley varieties for the incidence of loose smut infection and its relation to the size of seed borne on different parts of the spike (Experiments i a, b).

(b) seven varieties for the effect of seed size on some characters related to yield from infected and non-infected seeds (Experiment ii, a).

(c) nine varieties for the effect of seed size on some characters related to yield from non-inoculated seeds (Experiment ii, b) and

(d) three varieties for the effect of seed size on some characters related to yield from non-inoculated seeds sown at three different seeding rates (Experiment ii, c).

The main part of the first experiment was arranged together with the second experiment. Two additional sowings, as shown in Figure I, were included between the first and second and the second and third replications of the second experiment. In these sections (I, II), the same varieties which were used in the second experiment, except one (Parkland), were grown under conditions conducive to natural smut infection for subsequent study of the incidence of loose smut in different parts of the spike. One row 45 feet long from each of the six varieties was seeded in two additional sections

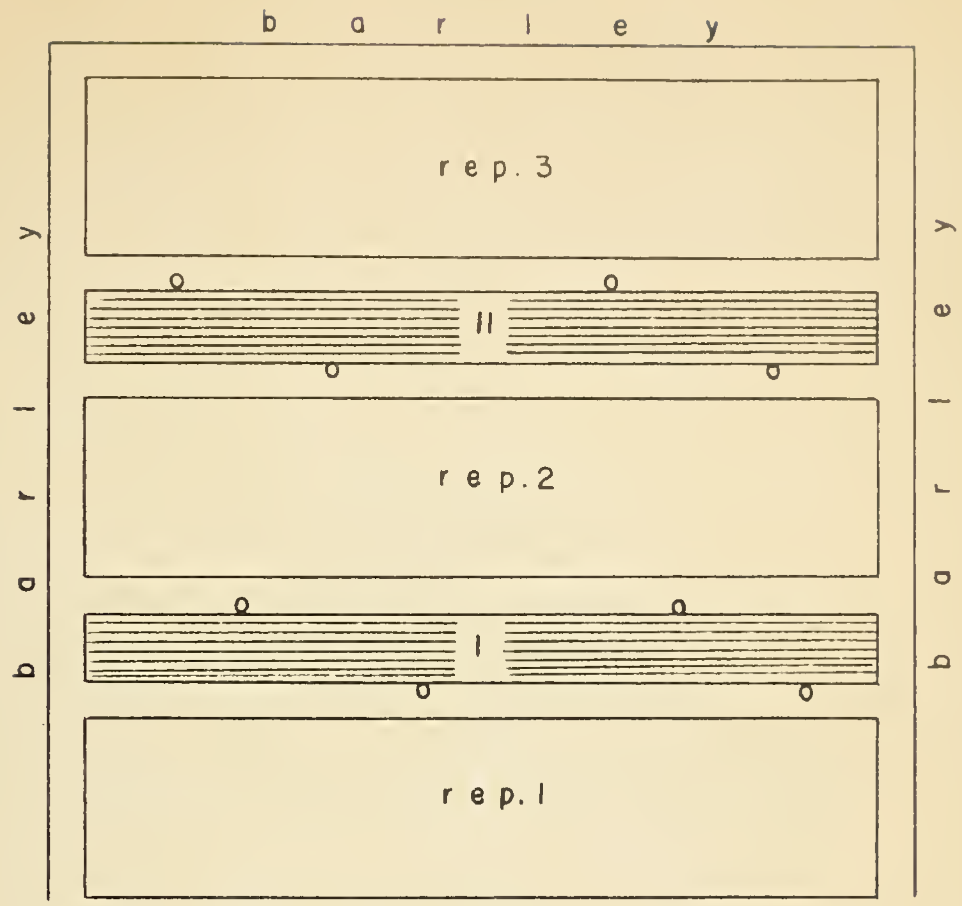

Figure I. Plan for 7 x 8 triple rectangular lattice together with two additional observations (I and II).
(0 refers to spore trap).

longitudinally, as shown in Figure 1. In this way the varieties were exposed to natural infection (checked by eight spore-traps) in two replications. On each day through the heading period, heads were tagged to record flowering date. These heads were harvested separately as to date and seeds from each head were divided into six categories according to location on the spike as mentioned before. In the second year seed relating to each variety, each date and each seed fraction were sown in a separate row and observed for the incidence of loose smut.

The second experiment was studied in a 7 x 8 triple rectangular lattice with three replications in which bulk, large, medium and small infected and non-infected seeds for each of the seven varieties were grown. Plots consisted of single rows 18-1/2 feet long and sown with a hand manipulated V-belt seeder.

The third experiment was arranged in a 6 x 6 triple lattice design with three replications accommodating nine varieties, each represented by bulk, large, medium and small seeds. Plots consisted of four 18-1/2 foot rows, spaced nine inches apart and sown with power seeder.

The fourth experiment which involved rates of seeding was conducted at the University of Alberta Parkland Farm in Edmonton and the Experimental Farm at Lacombe. Three varieties were tested in a randomized block with four replications. The seeding rates were based on the number of kernels per unit area, therefore, 560, 1120, 1680 kernels per plot were applied as rate I, rate II and

rate III, respectively. Each plot consisted of four rows 18-1/2 feet long and nine inches apart. A four-row power seeder was also used.

2. Method of collecting data

Data recorded for this study were based on number of seedlings, number of culms, number of loose-smutted heads, 1000-kernel weight and grain yield of the two center rows of 4-rowed plots. A foot on either end of all plots was discarded leaving 16-1/2 feet of the rows for the study.

At the two-to-three leaf stage the number of seedlings in two center rows of each plot were counted and recorded. The culms in the two center rows were counted and recorded shortly before maturity.

The number of smutted heads was counted daily from the time the first diseased head emerged from the sheath until the end of heading. Each smutted head was removed from the stem after it was counted.

At maturity only the center rows were harvested from each 4-row plot. The harvested plants were left to dry until a stable dry-weight was reached. Each plot was then threshed and total grain weight was recorded.

The 1000-kernel weight (in grams) was obtained by averaging the weight of four random 100-kernel samples from bulk seed for each plot.

3. Statistical analysis of data

Analyses of variances were performed directly on the data for number of seedlings, number of culms, 1000-kernel weight and grain yield. The percentage data on number of smutted heads were transformed by the square root procedure. The percentage data tended towards small values with many zeros. For this reason the square root transformation formula ($\sqrt{X + 0.5}$) was applied (33).

The percentage data on the incidence of loose smut infection in different parts of the spike from Experiment i a, b, were not analyzed statistically.

The data on above characters as related to yield obtained from Experiments ii, a, ii b, ii c which were carried out respectively in 7 x 8 triple rectangular lattice, 6 x 6 triple lattice and randomized blocks designs, were analyzed by standard methods as outlined in Cochran and Cox (6), Steel and Torrie (33) and Johnson (14, 15). Composite mean square and their degrees of freedom were calculated by the method given by Johnson and Keeping (16) when three or more main effects with two or more significant interactions were involved in an analysis of variance. The "F" test was used to determine signficant differences. In the determination of significant differences between totals and between means the L.S.D. (Least Significant Difference) method was applied.

IV. EXPERIMENTAL RESULTS

i. The incidence of loose smut infection and its relation to the size of the seed borne on different parts of the spike

The method of study was based on the comparison between total number of infected and non-infected spikes developed from seeds produced by central and lateral florets of the lower, middle and upper parts of the spikes.

(a) From artificial inoculation

In 1959, a preliminary experiment on the incidence of loose smut in different parts of the spike was conducted in the greenhouse. One sample of spikes from Titan and two different samples from Newal barley were used. One of the samples of Newal had been artificially inoculated by hand in 1938. The heads had been dusted heavily with dry chlamydospores of *Ustilago nuda* during the development of the spikes (31). The other sample of Newal was inoculated together with Titan by using the partial vacuum method at the University Parkland Farm in Edmonton in 1959.

Seeds relating to each sample and each seed fraction were sown in one or two separate rows in a greenhouse bench and observed for incidence of loose smut. The results obtained are summarized in Table 3, together with the percentage of spikes showing loose smut.

These results indicate that there was not much difference in the average percentage of smutted heads from the seeds developed from central and lateral florets.

Table 3. Number and percentage of smutted heads from central and lateral kernels of different parts of the spike

Variety	Part of spike	Total heads from: Central kernels	Total heads from: Lateral kernels	Smutted heads from: Central kernels	Smutted heads from: Lateral kernels	Per cent smutted heads from: Central kernels	Per cent smutted heads from: Lateral kernels
Titan (1959)	Lower 1/3	113	94	52	45	46.0	47.9
	Middle 1/3	78	96	37	45	47.4	46.9
	Upper 1/3	43	16	24	12	55.8	75.0
		234	206	113	102	48.3	49.5
Newal (1959)	Lower 1/3	75	98	24	29	32.0	29.6
	Middle 1/3	115	145	40	51	34.8	35.2
	Upper 1/3	121	118	48	43	39.7	36.4
		311	361	112	123	36.0	34.1
Newal (1938)	Lower 1/3	57	59	17	17	29.8	28.8
	Middle 1/3	73	65	25	22	34.3	33.9
	Upper 1/3	74	98	29	40	39.2	40.8
		204	222	71	79	34.8	35.6

On the average, slightly more loose-smut infection occurred in the plants grown from lateral seeds for the varieties Titan and Newal (1938), while the reverse was true for the Newal (1959), slightly more infection occurred in plants from central seeds.

Variety Titan showed higher amount of loose smut for both lateral and central seed fractions than two samples of Newal.

Artificial inoculation resulted in practically an equal amount of loose smut development for the seeds developed from central and lateral florets, but there generally was an increase in smut

infection from the lower to upper part of the spike. The percentage of smutted heads showed a similar trend in all three samples. The percentage infection, over all samples, was highest in seeds developed at the upper part of the spike, almost intermediate at the middle and lowest at the lower part. For example, the seeds from the upper part, from the central and lateral florets, produced 55.8 and 75.0 per cent of smutted heads, respectively, while those from the lower part of the spike resulted in 46.0 and 47.9 per cent smutted heads.

It is interesting to note here that the considerably higher percentage of infection resulted from Newal grown from the 1938 seed stock. This indicates that the fungus remained viable as dormant mycelium within the embryo until 1960. Seeds were stored in a cool, dry place at the University Parkland Farm in Edmonton since 1938. As shown in Table 4, the germination of seed samples, under field conditions, was from 38.3 to 81.4 per cent for different seed fractions.

Table 4. Per cent germination and number and percentage smutted heads from seed fractions of Newal barley inoculated in 1938

1000-kernel weight of samples (original)	No. of kernels seeded	No. of seedlings	% germination	Total heads	No. of smutted heads	% smutted heads
45.00 grams	220	179	81.4	1792	0	0
38.25 "	220	127	57.8	1418	0	0
47.77 "	220	138	62.7	1503	0	0
34.40 "	225	126	56.0	1648	178	12.1
40.84 "	220	117	53.2	1425	133	10.3
37.07 "	220	110	50.0	1384	143	11.5
44.79 "	222	125	56.3	1429	49	3.6
25.53 "	225	151	67.1	1674	0	0
36.07 "	225	166	73.8	1746	0	0
37.04 "	225	103	45.8	1061	14	1.33
47.29 "	225	146	64.9	1501	0	0
47.30 "	232	129	55.6	1438	0	0
40.74 "	235	90	38.3	965	20	2.1
35.49 "	220	156	70.9	1687	0	0

In 1960, a supplementary experiment on the incidence of loose smut in different parts of the spike was conducted in the greenhouse using artificially inoculated Gateway variety. Developing heads had been previously inoculated with spores of Ustilago nuda by the partial vacuum method in the same year. Each seed fraction was seeded separately in the greenhouse during the winter and observed for the incidence of loose smut. The results obtained are summarized in Table 5.

Table 5. Number and percentage of smutted heads from central and lateral kernels of different parts of the spike (Gateway)

		Total heads from		Smutted heads from		Per cent smutted heads from	
Variety	Part of spike	Central kernels	Lateral kernels	Central kernels	Lateral kernels	Central kernels	Lateral kernels
Gateway	Lower 1/3	187	213	37	74	19.8	34.7
	Middle 1/3	197	199	37	38	18.8	19.1
	Upper 1/3	164	244	38	67	23.2	27.5
		548	656	112	179	20.4	27.3

The results showed that on the average, over all seed fractions, seven per cent more smut infection occurred in plants from lateral seeds than in plants from central seeds.

In plants from lateral kernels of lower part of the spikes, infection percentage was somewhat higher than in plants from the upper part of the spikes. Less smut infection was present in plants grown from seed developed at the middle part than those of the other two parts.

(b) Under natural conditions

In 1959, six barley varieties which were used as infected materials to study the effect of seed size on yield, as influenced by infected embryos (Experiment ii, a), were exposed to natural infection in two replications. On each day through the heading period, smut spores in the air were checked by eight spore-traps, stage of ovary development was determined and heads were tagged to record flowering date. Tagged heads were harvested individually and seeds were separated into six fractions. Seeds relating to each variety, each date and each fraction, were sown in separate rows in the field and observed for incidence of loose smut. Data on percentage infection were based on the counts of smutted and normal heads. The results obtained are summarized in Tables 6, 7 and 8.

Table 6 shows the optimum period for infection of loose smut for each variety together with the density of the smut spores in the air during the flowering time. The optimum period was accepted as a period from dehiscence of pollen to the early stage of the fertilization (30). Spore density in the air was determined from examination of spore-traps consisting of slides, which were partly smeared with vaseline.

Twenty-four slides were examined each day under a microscope, and the relative amount of spores in the area which was smeared with vaseline, on each slide were recorded as 0 (none), 1 (very low), 2 (low), 3 (medium), 4 (high), and 5 (very high). Average spore density for each day, as shown in Table 6, indicated that spore density

Table 6. Optimum period for infection of loose smut for varieties together with heading period and density of spores in the air

Heading	Spore	Parkland						Montcalm						Gateway						Wolfe						Compana			Herta		
		Central			Lateral			Central			Lateral			Central			Lateral			Central			Lateral								
period	density	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U
July 9, 1959	0.75																														
10	0.08														Flowering						Flowering										
11	0.17																			+							Flowering				
12	2.88															+				+			+	+	+						
13	0.50		Flowering												+	+				+	+	+	+	+	+			+			
14	1.65														+	+		+	+	+	+	+	+	+	+	+	+	+			
15	2.70	+	+			+			Flowering					+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			
16	0.35	+	+	+		+	+				+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			
17	1.45	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		Flowering	
18	1.05	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+
19	2.05	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+			+	+	+
20	5.00	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+				+	+	+
21	2.40			+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+		+	+	+				+	+	+
22	1.80				+	+	+	+	+	+	+	+	+	+	+	+	+	+	+				+		+				+	+	+
23	3.55					+	+	+	+	+	+	+	+	+	+	+	+	+	+										+	+	+
24	3.88								+	+	+	+	+	+			+	+	+										+	+	+
25	2.00									+		+	+				+		+											+	+
26	3.65											+	+						+												
27	2.25																														
28	0.20																														

L refers to lower part of the spike.

M refers to middle part of the spike.

U refers to upper part of the spike.

varied from 0.08 to 5.00 during the heading period. This variation was probably caused by weather conditions, especially wind.

The optimum period differed to some extent in varieties, being longer for Gateway. There were also differences in optimum period between central and lateral florets within the same variety. Ovary development and dehiscence of anthers were found to be slower in lateral than in central kernels. A slightly longer period was also required for the development of flower parts in the lateral florets. This probably accounts for the greater infection in lateral florets. The percentage of smutted heads from the seeds related to each variety, each date and each fraction, as shown in Table 7, supported the previous evidence of greater infection in lateral kernels. This is true for varieties in which the florets remain open for a longer period of time during the flowering. The higher total percentages of infection occurred in Wolfe, Gateway and Montcalm, with moderate decline in Parkland and a greater drop for Compana.

The data show fewer infected plants grown from central than from lateral kernels. In the central kernels of Gateway and Wolfe the infection percentages were somewhat higher than in those of Parkland and Montcalm. The percentages of loose smut which developed from the central kernels of Parkland and Montcalm, were also lower as compared with the infection from lateral kernels of the same varieties.

Table 7. Percentage of smutted heads from the seeds related to each variety, each date and each seed fraction

Heading period	Average spore density	Parkland						Montcalm						Gateway						Wolfe					
		Central			Lateral			Central			Lateral			Central			Lateral			Central			Lateral		
		L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U	L	M	U
July 9, 1959	0.75																								
10	0.08																								
11	0.17																			2.3	-	-	-	-	-
12	2.88													-	-	1.1	-	-	-	1.0	1.0	-	4.4	6.7	-
13	0.50													-	-	-	-	-	-	1.0	0.5	0.5	0.6	3.1	[illegible]
14	1.65													2.0	-	-	2.9	-	-	-	-	-	4.0	-	[illegible]
15	2.70	-	-	-	-	0.7	-							-	-	-	2.5	1.3	-	-	-	-	-	3.5	[illegible]
16	0.35	-	-	0.7	-	-	0.8	-	-	-	0.7	-	2.6	0.4	-	-	0.6	-	1.6	-	-	1.3	1.9	1.9	-
17	1.45	-	-	-	-	-	-	-	-	0.6	-	0.6	1.2	1.8	0.5	-	-	1.7	-	-	-	-	2.2	8.3	[illegible]
18	1.05	-	-	-	-	1.9	1.4	-	0.6	-	3.1	0.6	-	3.2	-	0.6	0.5	1.6	1.5	-	5.3	-	-	-	-
19	2.05	-	-	3.7	4.2	-	9.5	-	-	-	-	-	1.8	-	-	-	-	-	-	-	-	-	-	-	[illegible]
20	5.00	-	-	-	-	-	-	-	-	0.6	0.8	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-
21	2.40	-	-	-	-	-	-	-	-	-	4.4	2.9	-	-	-	-	4.9	3.4	1.3						
22	1.80	-	-	-	4.7	-	0.9	-	-	-	3.7	1.2	6.1	-	1.1	-	0.6	0.5	2.0						
23	3.55	-	-	-	-	1.1	1.6	-	-	-	3.6	1.6	0.6	2.2	-	-	3.2	2.4	5.7						
24	3.88							-	-	-	-	2.0	-	-	-	-	-	-	6.2						
25	2.00							-	-	1.7	-	1.3	2.6												
26	3.65																								
27	2.25																								
28	0.20																								
		-	-	4.4	8.9	3.7	14.2	-	0.6	2.9	16.3	10.2	15.5	9.6	1.6	1.7	15.2	10.9	18.3	4.3	6.8	1.8	13.1	23.5	[illegible]

(1) L refers to lower part of the spike.
M refers to middle part of the spike.
U refers to upper part of the spike.

date and each seed fraction

'ay			Wolfe						Compana			Herta		
Lateral			Central			Lateral								
.	M	U	L	M	U	L	M	U	L	M	U	L	M	U
			2.3	-	-	-	-	-						
.	-	-	1.0	1.0	-	4.4	6.7	-						
.	-	-	1.0	0.5	0.5	0.6	3.1	7.6	-	-	0.7			
.9	-	-	-	-	-	4.0	-	1.9	-	-	-			
.5	1.3	-	-	-	-	-	3.5	4.8	-	-	-			
).6	-	1.6	-	-	1.3	1.9	1.9	-	-	1.1	-			
-	1.7	-	-	-	-	2.2	8.3	1.3	-	-	-			
).5	1.6	1.5	-	5.3	-	-	-	-	-	0.4	0.4			
-	-	-	-	-	-	-	-	4.7				0.4	0.4	0.8
-	-	-	-	-	-	-	-	-				-	-	-
.9	3.4	1.3										1.7	-	-
).6	0.5	2.0										0.8	1.1	0.4
.2	2.4	5.7										-	1.1	1.5
-	-	6.2										0.5	-	0.5
												-	0.4	0.7
.2	10.9	18.3	4.3	6.8	1.8	13.1	23.5	20.3	-	1.5	1.1	3.4	3.0	3.9

In total percentage of smutted heads, the heavier infections were present in plants grown from seeds developed from lateral florets of upper parts in Parkland and Gateway. However, the heavier infections were present in plants from lateral kernels of middle part of the spike in Wolfe and lateral kernels of the lower part of the spike in Montcalm. On the whole the infections were found to be lower in plants grown from kernels developed from the middle part of the spike in three out of the four six-rowed varieties. In the case of Wolfe, seeds from the middle parts of the spikes were found to be slightly more often infected than those from the upper parts, but considerably more often infected than those from the lower parts.

The data in Table 7 show no marked differences in smut resulting from seeds related to the different dates of flowering.

Table 8 shows the number and average percentage of smutted heads together with the total number of heads obtained from the experiment (i, b). The results indicated that in general, the average smut percentage in plants grown from lateral kernels were approximately double those in plants from central kernels. With regard to results from lateral kernels, no marked differences in average percentage infection were present between varieties, except Wolfe, in which the highest percentage of smut infection occurred.

During the winter of 1960, the incidence of loose smut in different parts of the spikes was studied in a supplementary greenhouse test with the three samples of York. The heads were collected from guard-rows of plots which showed very heavy infection during

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During the winter of 1960, the incidence of loose smut in different parts of the spikes was studied in a supplementary greenhouse test with the three samples of York. The heads were collected from guard-rows of plots which showed very heavy infection during

Table 8. Number and average percentage of smutted heads from central and lateral kernels of different parts of the spike

Variety	Part of spike	Total heads from Central kernels	Total heads from Lateral kernels	Smutted heads from Central kernels	Smutted heads from Lateral kernels	Per cent smutted heads from Central kernels	Per cent smutted heads from Lateral kernels
Parkland	Lower 1/3	194	190	0	8	0	4.21
	Middle 1/3	216	398	0	5	0	1.26
	Upper 1/3	261	508	5	11	1.92	2.17
		671	1096	5	24	0.74	2.19
Montcalm	Lower 1/3	218	825	0	22	0	2.67
	Middle 1/3	157	1072	1	15	0.64	1.40
	Upper 1/3	472	1142	4	25	0.85	2.19
		847	3039	5	62	0.59	2.04
Gateway	Lower 1/3	971	1079	17	21	1.75	1.95
	Middle 1/3	405	1241	3	22	0.74	1.77
	Upper 1/3	353	1076	3	29	0.85	2.70
		1729	3396	23	72	1.33	2.12
Wolfe	Lower 1/3	612	818	9	21	1.47	2.57
	Middle 1/3	561	927	10	42	1.78	4.53
	Upper 1/3	287	949	3	36	1.05	3.79
		1460	2694	22	99	1.51	3.67
Compana	Lower 1/3	504		0		0	
	Middle 1/3	532		4		0.75	
	Upper 1/3	552		3		0.54	
		1588		7		0.44	
Herta	Lower 1/3	972		8		0.82	
	Middle 1/3	1075		8		0.74	
	Upper 1/3	1291		10		0.77	
		3338		26		0.78	

heading period. These plots had been sown with the inoculated small, medium and large seed categories of York for the study carried out at the Experimental Farm in Lacombe. Seeds from each spike of the collected samples were separated into six fractions (on the basis mentioned before).

In the greenhouse, seeds relating to each sample and each fraction were seeded separately and observed for incidence of loose smut. The results obtained are summarized in Table 9, together with 1000-kernel weights for each fraction and the percentage of spikes showing loose smut.

Table 9. Number and percentage of smutted heads from central and lateral kernels from lower, middle and upper parts of the spike, together with 1000-kernel weight

		1000-kernel weight from		Total heads from		Smutted heads from		Per cent smutted heads from	
Sample	Part of spike	Cent. kern.	Lat. kern.	Cent. kern.	Lat. kern.	Cent. kern.	Lat. kern.	Cent. kern.	Lat. kern.
York I (small)	lower 1/3	38.44	29.70	183	138	8	16	4.37	11.59
	middle 1/3	41.95	35.93	182	158	12	23	6.59	12.71
	upper 1/3	38.52	29.28	192	188	5	16	2.60	8.51
		39.64	31.64	557	484	25	55	4.49	11.36
York II (medium)	lower 1/3	40.68	30.60	189	173	6	18	3.17	10.40
	middle 1/3	44.18	36.33	216	163	5	9	2.31	5.52
	upper 1/3	39.16	29.20	139	151	2	13	1.44	8.61
		41.34	32.04	544	487	13	40	2.39	8.21
York III (large)	lower 1/3	40.40	30.40	184	189	6	8	3.26	4.23
	middle 1/3	45.50	36.52	224	218	4	19	1.79	8.71
	upper 1/3	39.18	29.42	226	167	2	25	0.88	13.02
		41.69	32.11	634	574	12	52	1.89	9.06

The 1000-kernel weights of seeds used to produce the plants were slightly lower in the sample originally grown from small seeds than in those grown from medium and large.

The results of this experiment were in close agreement with previous results. There were marked differences in production of smutted heads between plants grown from central and from lateral kernels, there being much more smut in plants grown from lateral kernels. This was over twice as much in the first sample, three times as much in the second and four times in the third. The average percentage of smutted heads was higher for both lateral and central kernels in the first sample, which originally were grown from small sized seed, than in the other two samples.

The plants grown from the kernels developed on the lower, middle and upper parts of the spikes gave varying amounts of smutted heads for both central and lateral kernels within samples.

In general, these experiments indicate quite clearly that under natural conditions the amount of loose smut was much higher in plants grown from smaller lateral kernels than in those grown from larger central kernels.

ii. The effect of the seed size on some characters related to yield (Experiments ii a, b and c)

A. Number of seedlings

1. Experiment ii, a

Data on number of seedlings for each treatment and each replicate, obtained from seven varieties grown from infected and non-infected seeds are given in Appendix 1. The preliminary analysis of variance as a lattice experiment, S.E. for differences between treatment means, L.S.D. and relative precision of lattice design over the randomized block are also included. The preliminary analysisindicated that the treatment effect was highly significant.

The adjusted totals, over all replications, for varieties and seed categories are given in Table 10. The results of the analysis of variance for treatment components calculated from the adjusted totals are shown in Table 11.

Table 11. Partition of treatment effect into its components

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total (treatments)	19909.75	55				
Varieties	5570.89	6	928.48	<1 (1)		
Sizes	1562.90	3	520.97	4.74*	3.16	5.09
Infection	67.33	1	67.33	<1		
V x S	1663.26	18	92.40	<1		
V x I	8789.81	6	1464.97	13.32**	2.66	4.01
S x I	276.33	3	92.11	<1		
V x S x I (error)	1979.23	18	109.96			

(1) Tested against the significant first order interaction (V x I)

Table 10. Adjusted total number of seedlings over all replications, for varieties, infection and seed categories from Experiment ii, a at Lacombe in 1959

Variety	Infection	Seed size Large	Medium	Small	Bulk	Total
Parkland I	Non infected *	797.41	794.02	784.81	776.17	3152.41
	Infected (1.6%)*	808.49	781.22	728.71	782.62	3101.04
	Total	1605.90	1575.24	1513.52	1558.79	6253.45
Parkland II	Non infected	747.16	795.16	769.59	786.25	3098.16
	Infected (2.1%)	775.81	784.99	791.18	773.20	3125.18
	Total	1522.97	1580.15	1560.77	1559.45	6223.34
Montcalm	Non infected	787.69	802.13	783.39	808.62	3181.83
	Infected (2.1%)	803.33	796.18	780.43	805.84	3185.78
	Total	1591.02	1598.31	1563.82	1614.46	6367.61
Gateway	Non infected	805.37	801.01	770.03	813.94	3190.35
	Infected (2.0%)	734.22	719.24	705.94	701.16	2860.56
	Total	1539.59	1520.25	1475.97	1515.10	6050.91
Wolfe	Non infected	790.13	787.90	771.57	807.33	3156.93
	Infected (1.5%)	795.60	779.06	752.29	772.45	3099.40
	Total	1585.73	1566.96	1523.86	1579.78	6256.33
Compana	Non infected	728.59	719.38	679.18	700.97	2828.12
	Infected (1.3%)	764.99	799.54	755.09	819.97	3139.59
	Total	1493.58	1518.92	1434.27	1520.94	5967.71
Herta	Non infected	786.74	793.12	803.44	798.58	3181.88
	Infected (1.1%)	818.44	760.87	773.09	819.37	3171.77
	Total	1605.18	1553.99	1576.53	1617.95	6353.65
Total	Non infected	5443.09	5492.72	5362.01	5491.86	21789.68
	Infected	5500.88	5421.10	5286.73	5474.61	21683.32
	Total	10943.97	10913.82	10648.74	10966.47	43473.00

* The terms "non infected" and "infected" have been used in these tables to describe artificially non-inoculated and inoculated seeds, respectively.

The differences between varieties, in number of seedlings established, were found to be insignificant. The effect of seed size on number of seedlings was significant at the 5% level. The variance due to differences between infected and non-infected seeds did not reach significance, while the interaction between variety and infection was found to be highly significant.

2. <u>Experiment ii, b</u>

Data on number of seedlings for each treatment and each replication are given in Appendices 2 and 3 for each year of the study. The preliminary variance analyses of these data are presented in Appendix 4, together with the S.E. for differences between treatment means, L.S.D. and relative precision.

Highly significant treatment effects were obtained in both 1959 and 1960. There was a slight (six per cent) increase in precision in 1959 while it was considerably larger (238.5 per cent) in 1960.

The adjusted totals, over all replications, of varieties and seed categories for each year are given in Table 12. The analysis of variance for data on number of seedlings taken over both years is presented in Table 13.

Table 12. Adjusted total number of seedlings over all replications, for varieties and seed categories from Experiment ii, b at Lacombe in 1959 and 1960

		Seed size				
Varieties	Year	Large	Medium	Small	Bulk	Total
Gateway	1959	1425.59	1324.00	1305.60	1415.49	5470.68
	1960	1463.23	1733.16	1535.02	1528.90	6260.31
	Total	2888.82	3057.16	2840.62	2944.39	11730.99
Husky	1959	1477.93	1488.65	1561.23	1511.48	6039.29
	1960	1371.56	1678.66	1605.97	1475.22	6131.41
	Total	2849.49	3167.31	3167.20	2986.70	12170.70
Parkland	1959	1454.29	1469.95	1409.76	1437.40	5771.40
	1960	1515.95	1661.46	1501.51	1523.83	6202.75
	Total	2970.24	3131.41	2911.27	2961.23	11974.15
Olli	1959	1392.66	1376.53	1300.48	1320.78	5390.45
	1960	1393.30	1592.14	1487.75	1602.03	6075.22
	Total	2785.96	2968.67	2788.23	2922.81	11465.67
Pirkka	1959	1394.78	1168.97	1271.87	1376.18	5211.80
	1960	1592.81	1515.31	1313.12	1417.08	5838.32
	Total	2987.59	2684.28	2584.99	2793.26	11050.12
Wolfe	1959	1480.09	1525.98	1531.71	1534.84	6072.62
	1960	1697.26	1615.27	1644.79	1717.25	6674.57
	Total	3177.35	3141.25	3176.50	3252.09	12747.19
O.A.C. 21	1959	1473.66	1514.58	1488.39	1443.74	5920.37
	1960	1509.08	1662.59	1365.49	1511.38	6048.54
	Total	2982.74	3177.17	2853.88	2955.12	11968.91
Nord	1959	1291.96	1346.17	1488.22	1426.96	5553.31
	1960	1487.78	1361.18	1570.02	1536.87	5955.85
	Total	2779.74	2707.35	3058.24	2963.83	11509.16
Fort	1959	1535.71	1492.37	1361.77	1475.23	5865.08
	1960	1640.08	1616.19	1408.34	1678.42	6343.03
	Total	3175.79	3108.56	2770.11	3153.65	12208.11
Total	1959	12926.67	12707.20	12719.03	12942.10	51295.00
	1960	13671.05	14435.96	13432.01	13990.98	55530.00
	Total	26597.72	27143.16	26151.04	26933.08	106825.00

Table 13. Analysis of variance of 1959-1960 data on number of seedlings from Experiment ii, b

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	319889.60	71				
Varieties	84626.61	8	10578.33	5.81**	2.36	3.36
Seed sizes	10414.51	3	3471.50	1.91	3.01	
Years	83033.53	1	83033.53	45.62**	4.26	7.82
V x S	68900.68	24	2870.86	1.58	1.98	
V x Y	16872.93	8	2109.12	1.16	2.36	
S x Y	12359.09	3	4119.70	2.26	3.01	
V x S x Y (error)	43682.25	24	1820.09			

Variety and year effects on number of seedlings were found to be highly significant. Differences in number of seedlings between seed sizes were non-significant and there did not appear to be any improvement as seed size increased. All the first order interactions involving varieties, years and sizes were non-significant.

Varieties within different seed categories did not show consistent relative positions in the two years.

3. Experiment ii, c

The data on number of seedlings from experiments conducted at two locations for two years, are presented in Appendices 5 and 6. Actual data per plot and treatment means are given separately for each year and each location. The analyses of variance resulting from each experiment together with the L.S.D. and C.V. are also given at the bottom of the corresponding tables.

The analyses of variance indicate highly significant treatment effects for each of the experiments.

Total number of seedlings for varieties, seed categories and for different rates of seeding over all replications and for each experiment are given in Tables 14 and 15.

The partition of treatment effect into its components calculated from the data of Tables 14 and 15, for each year of the study are also given in the pertinent table for each experiment. Significance of main effects and interactions obtained from the analysis of components of treatments are summarized in Table 16.

Table 16. Significance of main effects and interactions for number of seedlings, Experiment ii, c

	Lacombe		Edmonton
Source of variation	1959	1960	1960
Treatments	**	**	**
Varieties	*	N.S.	N.S.
Rates	**	**	**
Linear	**	**	**
Quadratic	N.S.	N.S.	N.S.
Seed sizes	N.S.	N.S.	N.S.
V x R	N.S.	N.S.	N.S.
V x S	N.S.	N.S.	N.S.
R x S	N.S.	N.S.	N.S.

* Significant at the 5% level.

** Significant at the 1% level.

N.S. Non-significant ($P < 0.05$).

Table 14. Total number of seedlings over all replications, for varieties, seed categories and rates of seeding from Experiment ii, c at Lacombe in 1959 and 1960

Varieties	Sizes	Rates of seeding I	II	III	Total	Varieties	Sizes	Rates of seeding I	II	III	Total
Gateway	Large	673	1473	2271	4417	Gateway	Large	981	1846	2745	5572
	Medium	680	1485	2202	4367		Medium	1021	2062	3358	6441
	Small	769	1632	2284	4685		Small	1034	1930	3098	6062
	Total	2122	4590	6757	13469		Total	3036	5838	9201	18075
Husky	Large	706	1509	2312	4527	Husky	Large	956	1833	2712	5501
	Medium	782	1511	2313	4606		Medium	986	1986	2906	5878
	Small	521	1631	2410	4562		Small	928	1954	2758	5640
	Total	2009	4651	7035	13695		Total	2870	5773	8376	17019
Wolfe	Large	803	1621	2563	4987	Wolfe	Large	951	2001	2994	5946
	Medium	816	1625	2469	4910		Medium	910	1930	2838	5678
	Small	753	1514	2426	4693		Small	977	2096	3092	6165
	Total	2372	4760	7458	14590		Total	2838	6027	8924	17789
Total	Large	2182	4603	7146	13931	Total	Large	2888	5680	8451	17019
	Medium	2278	4621	6984	13883		Medium	2917	5978	9102	17997
	Small	2043	4777	7120	13940		Small	2939	5980	8948	17867
	Total	6503	14001	21250	41754		Total	8744	17638	26501	52883

Partition of treatment effects

Components	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%	1%
Total (treat.)	3072861.67	26			4488188.03	26				
Varieties	19525.39	2	9762.69	7.60*	16572.52	2	8286.26	3.81	4.46	8.65
Rate	3020759.39	2	1510379.69	1175.69**	4379324.53	2	2189662.26	1005.95**	4.46	8.65
Linear	3020472.34	1	3020472.34	2351.15**	4379320.12	1	4379320.12	2011.91**	5.32	11.26
Quadratic	287.04	1	287.04	<1	4.74	1	4.74	<1		
Size	52.17	2	26.08	<1	15671.19	2	7835.59	3.60	4.46	8.65
V x R	8228.89	4	2057.22	1.60	18081.01	4	4520.25	2.08	3.84	7.01
V x S	8956.27	4	2239.07	1.74	31938.53	4	7984.63	3.67	3.84	7.01
R x S	5062.11	4	1265.33	<1	9186.67	4	2296.67	1.06	3.84	7.01
VxRxS (E.)	10277.45	8	1284.68		17413.58	8	2176.70			

Table 15. Total number of seedlings over all replications, for varieties, seed categories and rates of seeding from Experiment ii, c at Edmonton in 1960

Varieties	Sizes	Rate of seeding I	II	III	Total
Gateway	Large	823	1710	2545	5078
	Medium	838	1778	2499	5115
	Small	844	1535	2420	4799
	Total	2505	5025	7464	14992
Husky	Large	814	1630	2631	5075
	Medium	829	1781	2563	5173
	Small	821	1612	2530	4963
	Total	2464	5023	7724	15211
Wolfe	Large	855	1747	2620	5222
	Medium	797	1716	2652	5165
	Small	780	1713	2609	5102
	Total	2432	5176	7881	15489
Total	Large	2492	5087	7796	15375
	Medium	2464	5275	7714	15453
	Small	2445	4860	7559	14864
	Total	7401	15222	23069	45692

Partition of treatment effect

Components	S.S.	D.F.	M.S.	F.	5%	1%
Total (treat.)	3435226.91	26				
Varieties	3446.79	2	1723.39	2.58	4.46	8.65
Rate	3409534.02	2	1704767.01	2552.35**	4.46	8.65
Linear	3409530.88	1	3409530.88	5104.70**	4.32	11.26
Quadr.	3.13	1	3.13	<1		
Size	5686.35	2	2843.17	4.26	4.46	8.65
V x R	5469.60	4	1367.40	2.05	3.84	7.01
V x S	1728.43	4	432.11	<1		
R x S	4018.37	4	1004.59	1.50	3.84	7.01
V x R x S (E.)	5343.35	8	667.92			

The results given in Table 16 show highly significant treatment effects were present in all tests.

Varieties were significantly different in number of seedlings at Lacombe in 1959, but not in 1960. The effect of rates of seeding were found to be highly significant for all three tests. The effect of rates of seeding is shown to have highly significant linearity in each test. This indicates that the number of seedlings increased in a straight line association with increase in rate of seeding. No significant quadratic effect was detected. Size of seed had no significant effect on the number of seedlings established. There were no significant interactions between varieties, rates and sizes in any combination in any of the tests.

Table 17 shows the analysis of two-year combined data on number of seedlings from tests conducted at Lacombe during the period of the 1959 and 1960. The number of seedlings in the Edmonton test was not determined.

Table 17. Analysis of variance of combined data on number of seedlings, from Experiment ii, c conducted at Lacombe in 1959 and 1960

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	8134450.8	215				
Treatments	7406222.0	26	284854.69	47.84**	1.95	2.58
Years	573401.2	1	573401.20	96.29**	4.23	7.72
T × Y	154827.6	26	5954.91	5.42**	1.61	1.95
Pooled error		162	1098.56			

Interaction used as valid error for the treatments and years main effects

Pooled error used as valid error for interaction (6).

The results showed the F values for treatments and years and the interaction between treatments and years to be highly significant. This means that, besides the treatment effect, number of seedlings may also be influenced by the year of testing.

B. Number of culms

1. Experiment ii, a

Data on number of culms per plot and unadjusted and adjusted treatment means are given in Appendix 7, together with the results of analysis of variance.

The analysis showed highly significant treatment effects on number of culms produced.

The results of the partition of treatment effect into its components calculated from adjusted total data of Table 18 are given in Table 19.

Table 19. Partition of treatment effect into its components

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Totals (treatments)	2793888.1	55				
Varieties	2562183.2	6	427030.53	525.07**(1)	2.66	4.01
Sizes	139980.7	3	46660.22	46.03**	3.16	5.09
Infection	1517.8	1	1517.77	1.50	4.41	
V x S	21597.1	18	1199.84	1.18	2.19	
V x I	48796.8	6	8132.81	8.02**	2.66	4.01
S x I	1566.3	3	522.11	<1		
V x S x I (error)	18246.3	18	1013.68			

(1) Tested against the significant first order interaction (V x I).

Table 18. Adjusted total number of culms over all replications, for varieties, infection and seed categories from Experiment ii, a at Lacombe in 1959

		Seed size				
Variety	Infection	Large	Medium	Small	Bulk	Total
Parkland I	Non infected	1019.33	922.02	841.45	968.32	3751.12
	Infected (1.6%)	930.34	869.99	785.82	856.30	3442.45
	Total	1949.67	1792.01	1627.27	1824.62	7193.57
Parkland II	Non infected	1005.08	968.79	866.17	900.46	3740.50
	Infected (2.1%)	949.13	843.00	810.90	927.58	3530.61
	Total	1954.21	1811.79	1677.07	1828.04	7271.11
Montcalm	Non infected	1085.22	989.29	823.22	959.75	3857.48
	Infected (2.1%)	1041.96	974.25	856.00	889.81	3762.02
	Total	2127.18	1963.54	1679.22	1849.56	7619.50
Gateway	Non infected	1374.13	1260.76	987.17	1312.98	4935.04
	Infected (2.0%)	1208.61	1131.16	988.32	1094.59	4422.68
	Total	2582.74	2391.92	1975.49	2407.57	9357.72
Wolfe	Non infected	1213.87	1037.43	939.58	1073.79	4264.67
	Infected (1.5%)	1066.99	1048.59	871.96	1012.54	4000.08
	Total	2280.86	2086.02	1811.54	2086.33	8264.75
Compana	Non infected	2116.37	2005.96	1757.88	1969.33	7849.54
	Infected (1.3%)	2137.89	2058.09	1733.62	1954.24	7883.84
	Total	4254.26	4064.05	3491.50	3923.57	15733.38
Herta	Non infected	1542.04	1467.56	1291.25	1389.28	5690.13
	Infected (1.1%)	1690.93	1587.39	1457.62	1805.90	6541.84
	Total	3232.97	3054.95	2748.87	3195.18	12231.97
Total	Non infected	9356.04	8651.81	7506.72	8573.91	34088.48
	Infected	9025.85	8512.47	7504.24	8540.96	33583.52
	Total	18381.89	17164.28	15010.96	17114.87	67672.00

The results indicate highly significant differences in number of culms between varieties. The effect of seed size was also highly significant. The number of culms tended to increase with increasing seed size in all varieties. The variance due to infected and non-infected seeds sown did not reach the point of significant difference. There was no significant interaction between variety and seed size. It is assumed that varietal differences were expressed equally over the full range of seed sizes used. A highly significant interaction between variety and infection (infected and non-infected) was shown.

2. Experiment ii, b

Data on number of culms per plot, together with unadjusted and adjusted treatment means are presented in Appendices 8 and 9 for each year of the study. The analyses of variance of these data are given in Appendix 10, together with the S.E. differences between treatment means, L.S.D. and relative precision.

Highly significant treatment effects were present in both analyses. A slight increase (10 per cent) in precision was found in 1959 and a large increase (142 per cent) in 1960.

Adjusted total number of culms over all replications, for varieties and seed categories are given in Table 20. The results of the analysis of variance from the combined data of Table 20 are presented in Table 21.

Table 20. Adjusted total number of culms over all replications, for varieties and seed categories from Experiment ii, b at Lacombe in 1959 and 1960

Varieties	Years	Seed size Large	Medium	Small	Bulk	Total
Gateway	1959	2684.21	2389.04	2320.01	2474.56	9867.82
	1960	2824.84	2437.62	2333.56	2663.73	10259.75
	Total	5509.05	4826.66	4653.57	5138.29	20127.57
Husky	1959	2083.68	1958.19	2014.35	1998.32	8054.54
	1960	2074.56	2324.94	2213.69	2207.27	8820.46
	Total	4158.24	4283.13	4228.04	4205.59	16875.00
Parkland	1959	1830.72	1753.48	1728.93	1743.60	7056.73
	1960	2113.22	2083.95	1799.18	2027.65	8024.00
	Total	3943.94	3837.43	3528.11	3771.25	15080.73
Olli	1959	2097.36	1873.46	1755.10	1800.75	7526.67
	1960	2335.09	2081.68	1994.99	2168.12	8579.88
	Total	4432.45	3955.14	3750.09	3968.87	16106.55
Pirkka	1959	1805.35	1633.91	1637.11	1690.68	6767.05
	1960	2224.81	1950.68	1801.20	1939.28	7915.97
	Total	4030.16	3584.59	3438.31	3629.96	14683.02
Wolfe	1959	2418.95	2257.99	2163.88	2240.54	9081.36
	1960	2500.03	2121.34	2176.55	2432.02	9229.94
	Total	4918.98	4379.33	4340.43	4672.56	18311.30
O.A.C. 21	1959	1746.49	1728.06	1715.26	1772.51	6962.32
	1960	1973.87	2105.54	1825.68	1990.46	7895.55
	Total	3720.36	3833.60	3540.94	3762.97	14857.87
Nord	1959	1750.66	1799.41	1737.20	1919.00	7206.27
	1960	2244.06	1903.86	2053.91	2156.85	8358.68
	Total	3994.72	3703.27	3791.11	4075.85	15564.95
Fort	1959	1677.93	1610.10	1552.19	1549.02	6389.24
	1960	1937.71	2033.58	1743.13	1979.35	7693.77
	Total	3615.64	3643.68	3295.32	3528.37	14083.01
Total	1959	18095.35	17003.64	16624.03	17188.98	68912.00
	1960	20228.19	19043.19	17941.89	19564.73	76778.00
	Total	38323.54	36046.83	34565.92	36753.71	145690.00

Table 21. Analysis of variance of 1959-1960 data on number of culms from Experiment ii, b

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	1908486.70	71				
Varieties	1274443.72	8	159305.47	26.53**(1)	2.36	3.36
Seed sizes	135401.32	3	45133.77	19.83**	3.01	4.72
Years	286453.50	1	286453.50	47.70**(1)	4.26	7.82
V x S	98012.06	24	4083.84	1.79	1.98	
V x Y	48045.00	8	6005.63	2.64*	2.36	3.36
S x Y	11504.16	3	3834.72	1.68	3.01	
V x S x Y (error)	54626.94	24	2276.12			

(1) Tested against the significant first order interaction (V x Y).

The differences in number of culms between varieties, between seed categories and between years were found to be highly significant. The interaction between varieties and years was significant at the 5% level.

3. Experiment ii, c

Data on number of culms obtained from experiments conducted at two locations for two years are given in Appendices 11 and 12. Number of culms per plot and treatment means are shown for each year and each location separately. The analyses of variance resulting from each experiment together with the L.S.D. and C.V. are given at the bottom of the corresponding tables.

Analyses of variance showed a highly significant F value for treatment effects in each study.

Total numbers of culms for varieties, seed categories and for rates of seeding over all replications for each experiment are given in Tables 22 and 23 separately. The partition of the treatment

Table 22. Total number of culms over all replications, for varieties, seed categories and rates of seeding from Experiment ii, c at Lacombe in 1959 and 1960

Varieties	Sizes	Rates of seeding I	II	III	Total	Varieties	Sizes	Rate of seeding I	II	III	Total
Gateway	Large	2183	2994	3216	8393	Gateway	Large	2300	2936	3416	8652
	Medium	2032	2739	3251	8022		Medium	2089	2785	3687	8561
	Small	2109	2846	3173	8128		Small	2013	2845	3307	8165
	Total	6324	8579	9640	24543		Total	6402	8566	10410	25378
Husky	Large	1905	2400	2619	6924	Husky	Large	2129	2687	3067	7883
	Medium	1967	2164	2538	6669		Medium	2170	2715	3133	8018
	Small	1435	2132	2600	6167		Small	1801	2421	2926	7148
	Total	5307	6696	7757	19760		Total	6100	7823	9126	23049
Wolfe	Large	2335	2813	2823	7971	Wolfe	Large	2071	2749	3119	7939
	Medium	2150	2598	2748	7496		Medium	1707	2377	2966	7050
	Small	1883	2361	2730	6974		Small	1712	2462	3265	7439
	Total	6368	7712	8301	22441		Total	5490	7588	9350	22428
Total	Large	6423	8207	8658	23288	Total	Large	6500	8372	9602	24474
	Medium	6149	7501	8537	22187		Medium	5966	7877	9786	23629
	Small	5427	7339	8503	21269		Small	5526	7728	9498	22752
	Total	17999	23047	25698	66744		Total	17992	23977	28886	70855

Partition of treatment effects

Components	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%	1%
Total (treat.)	1333497.50	26			1935750.25	26				
Varieties	319289.30	2	159644.65	13.87*(1)	134373.85	2	67186.92	23.90**	4.46	8.65
Rate	849858.30	2	424929.15	36.93**(1)	1653682.75	2	826841.37	294.09**	4.46	8.65
Linear	823258.30	1	823258.30	71.55**(1)	1648322.72	1	1648322.72	586.27**	5.32	11.26
Quadr.	26600.00	1	26600.00	2.31 (1)	5766.00	1	5766.00	2.05	5.32	11.26
Size	56771.10	2	28385.55	10.47**	41189.15	2	20594.57	7.32*	4.46	8.65
V x R	46022.06	4	11505.52	4.25*	23438.36	4	5859.59	2.08	3.84	7.01
V x S	15487.26	4	3871.82	1.43	39623.63	4	9905.91	3.52	3.84	7.01
R x S	24388.60	4	6097.15	2.25	20950.06	4	5237.52	1.86	3.84	7.01
V x R x S(E.)	21680.88	8	2710.11		22492.45	8	2811.56			

(1) Tested against the significant first order interaction (V x R).

Table 23. Total number of culms over all replications, for varieties, seed categories and rate of seeding from Experiment ii, c at Edmonton in 1959 and 1960

Varieties	Sizes	Rates of seeding I	II	III	Total	Varieties	Sizes	Rates of seeding I	II	III	Total
Gateway	Large	2777	3886	4623	11286	Gateway	Large	2984	4469	5213	12666
	Medium	2685	4047	4448	11180		Medium	2817	4334	5294	12445
	Small	2400	3542	4110	10052		Small	2781	3934	5171	11886
	Total	7862	11475	13181	32518		Total	8582	12737	15678	36997
Husky	Large	2802	3525	4359	10686	Husky	Large	3026	4030	4270	11326
	Medium	2342	3405	3819	9566		Medium	3010	3961	4368	11339
	Small	1972	3439	4001	9412		Small	2764	3675	4182	10621
	Total	7116	10369	12179	29664		Total	8800	11666	12820	33286
Wolfe	Large	2602	3436	3876	9914	Wolfe	Large	3193	4266	4047	11506
	Medium	2513	3877	3544	9934		Medium	2723	3835	4015	10573
	Small	2254	3269	3856	9379		Small	2315	3602	3835	9752
	Total	7369	10582	11276	29227		Total	8231	11703	11897	31831
Total	Large	8181	10847	12858	31886	Total	Large	9203	12765	13530	35498
	Medium	7540	11329	11811	30680		Medium	8550	12130	13677	34357
	Small	6626	10250	11967	28843		Small	7860	11211	13188	32259
	Total	22347	32426	36636	91409		Total	25613	36106	40395	102114

Partition of treatment effects

Components	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%	1%
Total (treat.)	3523670.70	26			4175172.60	26				
Varieties	177471.90	2	88735.95	14.96**	394223.20	2	197111.60	2.20(1)	5.79	13.27
Rate	2995239.50	2	1497619.75	252.55**	3213019.40	2	1606509.70	19.54**	6.94	18.00
Linear	2835771.12	1	2835771.12	478.21**	3034826.72	1	3034826.72	36.92**	7.71	21.20
Quadr.	159468.34	1	159468.34	26.89**	178192.67	1	178192.67	2.16	7.71	21.20
Size	130452.40	2	65226.20	11.00**	149950.10	2	74975.05	8.01*	6.94	18.00
V x R	55252.18	4	13813.05	2.33	328779.80	4	82194.95	36.00**	3.84	7.01
V x S	44609.28	4	11152.32	1.88	33480.10	4	8370.02	3.67	3.84	7.01
R x S	73206.01	4	18301.50	3.09	37454.20	4	9363.55	4.10*	3.84	7.01
V x R x S (E.)	47439.43	8	5929.93		18265.80	8	2283.22			

(1) Calculated composite mean square and tested against composite valid error.

effect into its components based on these data are also given at the bottom of the same tables. The results of these analyses are summarized in Table 24.

Table 24. Significance of main effects and interactions for number of culms from Experiment ii, c

Source of variation	Lacombe		Edmonton	
	1959	1960	1959	1960
Treatments	**	**	**	**
Varieties	*	**	**	N.S.
Rates	**	**	**	**
Linear	**	**	**	**
Quadratic	N.S.	N.S.	**	*
Seed sizes	**	*	**	**
V x R	*	N.S.	N.S.	N.S.
V x S	N.S.	N.S.	N.S.	N.S.
R x S	N.S.	N.S.	N.S.	*

* Significant at the 5% level.
** Significant at the 1% level.
N.S. Non-significant ($P \angle 0.05$).

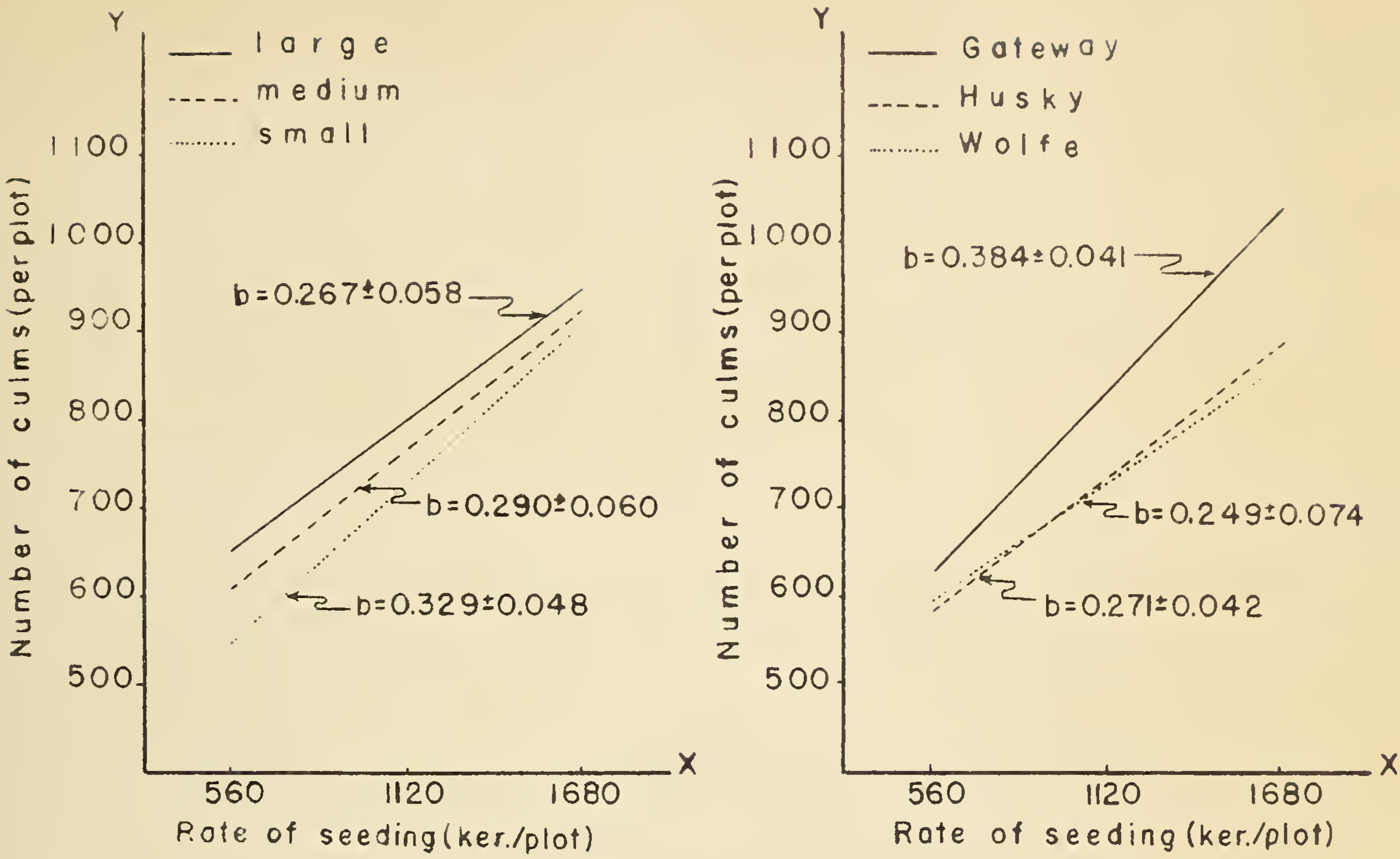
This analysis shows that, in the Lacombe tests, variation in number of culms due to different varieties was significant at the 5% level in 1959 and at the 1% level in 1960. In the Edmonton test it was significant only in 1959. The variation in the same character due to different rates of seeding was very highly significant in each experiment at both locations and for both years. The linear effect of rates was also found to be highly significant. The quadratic effect, although non-significant in Lacombe tests in

both years, was significant at the 1% and 5% level at Edmonton in 1959 and 1960, respectively. The significant linear relation indicated that there was a progressive increase in the number of culms as the rate of seeding was increased. The significant quadratic effect indicated that the increase in number of culms in Edmonton tests did not have a straight-line association with increase in rate of seeding. The variation in number of culms due to different seed categories sown was also found to be highly significant for each experiment. The significant interactions were found only between variety and rate of seeding in the 1959 Lacombe test and between rate of seeding and seed size in the 1960 Edmonton test.

The graphical analyses of the differences in response to the rate of seeding within seed categories and within varieties are shown in Figure 2.

The regression lines together with regression coefficients showed that the response of culm production to the variation in rate of seeding was generally similar between seed categories. The plants grown from small seeds showed slightly higher response to the increasing rate of seeding than two other categories. Among varieties, Gateway was more sensitive than the other varieties to variation in rate of seeding.

Table 25 shows the analysis of the combined two years data on number of culms from Experiment ii, c conducted at two locations.



Size	R.I	R.II	R.III
Large	631	837	930
Medium	588	809	913
Small	530	761	899

Variety	R.I	R.II	R.III
Gateway	608	862	1038
Husky	569	762	873
Wolfe	572	783	851

Figure 2. Number of culms per plot; linear regression of the differences in response to the rate of seeding within seed categories and within varieties, respectively.

Table 25. Analysis of variance of combined data on number of culms from Experiment ii, c

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	22002672.0	431				
Treatments	9767139.2	26	375659.20	10.32**(1)	1.65	2.03
Locations	7239569.0	1	7239569.00	271.03**(2)	4.23	7.72
Years	508134.0	1	508134.00	5.05 (2)	161.4	
T x L	694499.8	26	26711.53	2.72**	1.46	1.70
T x Y	276545.8	26	10636.38	1.08	1.46	
L x Y	100650.0	1	100650.00	10.24**	3.84	6.63
T x L x Y	229906.2	26	8842.55	<1		
Plots treated alike (3)	3186228.0	324	9834.04			

(1) Composite mean square tested against composite valid error.
(2) Tested against the significant first order interaction (T x L, T x Y).
(3) Represents a pooling of the S.S. and D.F. for all sources of variations involving replicates.

The analysis indicates that the differences in number of culms due to locations were found to be highly significant while the differences due to years were insignificant. The interactions between treatments and locations and between locations and years were highly significant. The interaction between treatments and years did not reach the .05 significance point.

C. Number of loose smutted heads

1. Experiment ii, a

Transformed data on number of smutted heads per plot are given in Appendix 13, together with the analysis of variance, S.E. for difference between treatment means, and the L.S.D.

The analysis showed highly significant treatment effects.

Total number of smutted heads, over all replications, for varieties, infection and seed categories are given in Table 26. Partition of treatment effect into its components, calculated from the data of Table 27, are given in Table 27.

Table 27. Partition of treatment effect into its components

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total (treatments)	30.716	55				
Varieties	14.250	6	2.3750	3.05(1)	4.28	
Sizes	3.929	3	1.3097	6.17**	3.16	5.09
Infection	2.023	1	2.0230	2.60(1)		
V × S	1.995	18	0.1108	<1		
V × I	4.675	6	0.7792	3.67*	2.66	4.01
S × I	0.025	3	0.0083	<1		
V × S × I (error)	3.819	18	0.2122			

(1) Tested against the significant first order interaction (V × I).

On the basis of the analysis in Table 27, the relation of seed size to the number of smutted heads was found to be highly significant. The interaction between varieties and infections (inoculated and non-inoculated) was also significant at the 5% level. The significance of the seed size effect implies that the number of smutted heads was significantly different in plants grown from different seed categories. The number of smutted heads was higher in plants grown from small seeds than in those grown from medium and large seeds. The significant interaction indicates that the inoculated and non-inoculated seeds gave different results in different varieties. The differences in number of smutted heads were largest between plants grown from infected and non-infected seeds of varieties Montcalm, Wolfe and Compana. In Gateway and Parkland, the plants from non-inoculated seeds produced more smutted heads than did

Table 26. Transformed data on total number of smutted heads over all replications, for varieties, infection and seed categories from Experiment ii, a at Lacombe in 1959

Variety	Infection	Seed size: Large	Medium	Small	Bulk	Total
Parkland I	Non infected	2.909	5.477	4.949	4.060	17.395
	Infected (1.6%)	3.323	3.591	4.384	4.152	15.450
	Total	6.232	9.068	9.333	8.212	32.845
Parkland II	Non infected	2.910	4.795	5.268	4.221	17.194
	Infected (2.1%)	3.913	4.671	5.131	4.348	18.063
	Total	6.823	9.466	10.399	8.569	35.257
Montcalm	Non infected	2.303	2.521	2.936	2.130	9.890
	Infected (2.1%)	3.263	4.080	6.204	4.836	18.383
	Total	5.566	6.601	9.140	6.966	28.273
Gateway	Non infected	3.071	5.478	7.009	5.454	21.012
	Infected (2.0%)	4.176	6.208	3.888	4.543	18.815
	Total	7.247	11.686	10.897	9.997	39.827
Wolfe	Non infected	2.130	2.309	2.130	2.303	8.872
	Infected (1.5%)	2.560	4.537	4.871	3.392	15.360
	Total	4.690	6.846	7.001	5.695	24.232
Compana	Non infected	2.232	2.130	2.130	2.226	8.718
	Infected (1.3%)	3.286	3.363	4.622	3.506	14.777
	Total	5.518	5.493	6.752	5.732	23.495
Herta	Non infected	2.130	2.130	2.130	2.358	8.748
	Infected (1.1%)	2.353	2.245	2.379	2.440	9.417
	Total	4.483	4.375	4.509	4.798	18.165
Total	Non infected	17.685	24.840	26.552	22.752	91.829
	Infected	22.874	28.695	31.479	27.217	110.265
	Total	40.559	53.535	58.031	49.969	202.094

artificially infected seeds. Probably the seeds which were accepted as non-infected from Gateway and Parkland had been greatly influenced by the natural infection of loose smut in previous years.

2. <u>Experiment ii, b</u>

Transformed data on number of smutted heads are given in Appendices 14 and 15 for the tests made in 1959 and 1960, respectively. The analyses of variance, together with the S.E. for differences between treatment means and the L.S.D. for two years are presented in Appendix 16.

Analyses of variance showed highly significant treatment effects for each year of the study.

Transformed data on total number of smutted heads over all replications, for varieties, seed categories and years are given in Table 28. The partition of treatment effect into its components, calculated from transformed total data, are given in Table 29.

Table 29. Analysis of variance of 1959-1960 data on number of smutted heads from Experiment ii, b

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total (treatments)	25.431	71				
Varieties	11.777	8	1.472	2.11(1)	2.71	
Seed sizes	3.107	3	1.036	6.75**(2)	3.01	4.72
Years	0.254	1	0.254	<1 (2)		
V x S	3.693	24	0.154	2.30	1.98	2.66
V x Y	4.606	8	0.576	8.60**	2.36	3.36
S x Y	0.376	3	0.125	1.87	3.01	
V x S x Y (error)	1.618	24	0.067			

(1) Composite mean square tested against the composite valid error.
(2) Tested against the significant first order interactions (V x S, V x Y).

Table 28. Transformed data on total number of smutted heads over all replications, for varieties and seed categories from Experiment ii, b at Lacombe in 1959 and 1960

		Seed size				
Varieties	Years	Large	Medium	Small	Bulk	Total
Gateway	1959	3.038	4.382	4.549	4.146	16.115
	1960	2.722	3.070	3.666	3.024	12.482
	Total	5.760	7.452	8.215	7.170	28.597
Husky	1959	2.130	2.777	4.338	3.565	12.810
	1960	3.201	4.969	8.065	5.501	21.736
	Total	5.331	7.746	12.403	9.066	34.546
Parkland	1959	3.317	4.071	4.068	4.683	16.139
	1960	2.251	3.876	3.887	3.517	13.531
	Total	5.568	7.947	7.955	8.200	29.670
Olli	1959	2.130	2.130	2.130	2.130	8.520
	1960	2.232	2.601	2.130	2.359	9.322
	Total	4.362	4.731	4.260	4.489	17.842
Pirkka	1959	2.130	2.257	2.363	2.245	8.995
	1960	2.130	2.130	3.191	2.130	9.581
	Total	4.260	4.387	5.554	4.375	18.576
Wolfe	1959	2.730	2.286	2.404	2.130	8.950
	1960	2.732	2.837	4.360	2.811	12.740
	Total	4.862	5.123	6.764	4.941	21.690
O.A.C. 21	1959	2.430	2.783	3.345	2.550	11.108
	1960	2.378	2.130	2.999	2.559	10.066
	Total	4.808	4.913	6.344	5.109	21.174
Nord	1959	2.232	2.232	2.353	2.309	9.126
	1960	2.130	2.383	2.251	2.466	9.230
	Total	4.362	4.615	4.604	4.775	18.356
Fort	1959	2.580	3.817	3.524	3.073	12.994
	1960	3.585	2.130	4.053	3.697	13.465
	Total	6.165	5.947	7.577	6.770	26.459
Total	1959	22.117	26.735	29.074	26.831	104.757
	1960	23.361	26.126	34.602	28.064	112.153
	Total	45.478	52.861	63.676	54.895	216.910

The differences in number of smutted heads due to effect of seed size were found to be highly significant. Proportion of smutted heads increased as seed decreased in size. The variation in number of smutted heads between varieties did not reach significance in the analysis of variance. However, the L.S.D. calculated from totals, showed significant differences in number of smutted heads for varieties. The L.S.D. between paired variety totals was found to be 2.146 and 2.854 at the level of 5 and 1 per cent significance, respectively. The L.S.D. value of 3.027 for year totals indicated that the difference in infection was significant only for small seed. The interactions between varieties and seed categories and between varieties and years were significant at the 5 and 1 per cent level, respectively.

3. <u>Experiment ii, c</u>

Transformed data on number of smutted heads from the experiments conducted at two locations are given in Appendices 17 and 18. Number of smutted heads per plot and treatment means are shown separately for each year and each location.

The analyses of variance resulting from each experiment together with the L.S.D. and C.V. are given at the bottom of the corresponding tables.

Analyses of variance indicate highly significant treatment effects for each study.

Transformed total number of smutted heads over all replications for varieties, seed categories and rates of seeding and for each experiment are given in Tables 30 and 31. The S.E. and L.S.D. for the totals of seed categories and rates of seeding within varieties have been calculated. Similar calculations have been made for the totals of seed categories, rates of seeding and varieties within each experiment. The data obtained are shown in the pertinent table for each experiment.

It is necessary to examine the totals for varieties, seed categories and rates of seeding within varieties and within experiments when making comparisons between them. Significant differences in number of smutted heads were found between seed categories within varieties and between varieties within the test. The plants grown from small- and medium-sized seeds differed significantly in production of smutted heads as compared to plants grown from large seeds.

The different rates of seeding did not show significant differences in percentage of smutted heads.

Among varieties, Gateway with a total of 53.594 $\pm$ 1.244 smutted heads was most heavily infected in 1959, while Husky was most influenced at Lacombe and Edmonton in 1960, with totals of 63.508 $\pm$ 1.328 and 57.501 $\pm$ 1.244 (transformed data) smutted heads, respectively.

Table 30. Transformed data on total number of smutted heads and over all replications, for varieties, seed categories and rates of seeding from Experiment ii, c at Lacombe in 1959 and 1960

		Rate of seeding			
Varieties	Sizes	I	II	III	Total
Gateway	Large	3.596	3.638	3.711	10.945
	Medium	6.719	6.257	6.004	18.980
	Small	8.247	6.953	8.469	23.669
	Total	18.562	16.848	18.184	53.594
Husky	Large	2.840	3.052	3.189	9.081
	Medium	4.675	4.874	4.815	14.364
	Small	5.072	6.828	6.354	18.254
	Total	12.587	14.754	14.358	41.699
Wolfe	Large	3.130	2.840	2.840	8.810
	Medium	3.313	3.036	3.109	9.458
	Small	3.099	3.767	3.714	10.580
	Total	9.542	9.643	9.663	28.848
Total	Large	9.566	9.530	9.740	28.836
	Medium	14.707	14.167	13.928	42.802
	Small	16.418	17.548	18.537	52.503
	Total	40.691	41.245	42.205	124.141

For size and rate totals within varieties

Standard error $= \sqrt{(12)(0.043)} = 0.718$

L.S.D. $= 1.990 \sqrt{(12)(2)(0.043)} = 2.022$

$= 2.638 \sqrt{(12)(2)(0.043)} = 2.680$

For size, rate and variety totals

Standard error $= \sqrt{(36)(0.043)} = 1.244$

L.S.D. $= 1.990 \sqrt{(36)(2)(0.043)} = 3.502$

$= 2.638 \sqrt{(36)(2)(0.043)} = 4.643$

		Rate of seeding			
Varieties	Sizes	I	II	III	Total
Gateway	Large	3.321	3.351	3.681	10.353
	Medium	3.886	3.700	3.760	11.346
	Small	4.147	4.429	4.719	13.295
	Total	11.354	11.480	12.160	34.994
Husky	Large	3.892	4.089	4.664	12.645
	Medium	6.237	7.566	5.424	19.227
	Small	10.537	10.096	11.003	31.636
	Total	20.666	21.751	21.091	63.508
Wolfe	Large	3.979	3.561	4.219	11.759
	Medium	4.206	4.294	4.401	12.901
	Small	5.282	4.647	4.897	14.826
	Total	13.467	12.502	13.517	39.486
Total	Large	11.192	11.001	12.564	34.757
	Medium	14.329	15.560	13.585	43.474
	Small	19.966	19.172	20.619	59.757
	Total	45.487	45.733	46.768	137.988

For size and rate totals within varieties

Standard error $= \sqrt{(12)(0.049)} = 0.767$

L.S.D. $= 1.990 \sqrt{(12)(2)(0.049)} = 2.159$

$= 2.638 \sqrt{(12)(2)(0.049)} = 2.862$

For size, rate and variety totals

Standard error $= \sqrt{(36)(0.049)} = 1.328$

L.S.D. $= 1.990 \sqrt{(36)(2)(0.049)} = 3.737$

$= 2.638 \sqrt{(36)(2)(0.049)} = 4.954$

Table 31. Transformed data on total number of smutted heads over all replications, for varieties, seed categories and rates of seeding from Experiment ii, c at Edmonton in 1960

		Rate of seeding			
Varieties	Sizes	I	II	III	Total
Gateway	Large	3.616	3.252	3.567	10.435
	Medium	3.695	3.787	3.515	10.997
	Small	4.343	5.131	4.420	13.894
	Total	11.654	12.170	11.502	35.326
Husky	Large	3.583	3.556	4.255	11.194
	Medium	6.186	6.596	5.145	17.927
	Small	8.828	9.756	9.796	28.380
	Total	18.597	19.708	19.196	57.501
Wolfe	Large	3.109	3.653	4.035	10.797
	Medium	4.074	3.826	3.995	11.895
	Small	5.114	5.292	5.109	15.515
	Total	12.297	12.771	13.139	38.207
Total	Large	10.308	10.261	11.857	32.426
	Medium	13.955	14.209	12.655	40.819
	Small	18.285	20.179	19.325	57.789
	Total	42.548	44.649	43.837	131.034

For size and rate totals within varieties

Standard error = $\sqrt{(12)\ (0.043)} = 0.718$

L.S.D. = $1.990\ \sqrt{(12)(2)(0.043)} = 2.022$

= $2.638\ \sqrt{(12)(2)(0.043)} = 2.680$

For size, rate and variety totals

Standard error = $\sqrt{(36)\ (0.043)} = 1.244$

L.S.D. = $1.990\ \sqrt{(36)(2)(0.043)} = 3.502$

= $2.638\ \sqrt{(36)(2)(0.043)} = 4.643$

D. 1000-kernel weight

1. Experiment ii, a

Appendix 20 shows the gram weight of 1000-kernels, together with the results of analysis of variance, S.E., L.S.D. and relative precision. The analysis of variance indicates that the treatment effect was highly significant.

The adjusted totals over all replications for seed categories and for varieties grown from infected and non-infected seeds are given in Table 32. The results of the analysis of variance for treatment components calculated from the adjusted totals are shown in Table 33.

Table 33. Partition of treatment effect into its components

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total (treatments)	7270.30	55				
Varieties	7207.71	6	1201.29	208.27** (1)	3.37	5.80
Sizes	5.58	3	1.86	1.86 (2)	3.16	
Infection	2.00	1	2.00	<1		
V x S	17.91	18	1.00	2.27*	2.24	3.15
V x I	28.59	6	4.77	10.84**	2.66	4.01
S x I	0.65	3	0.22	<1		
V x S x I (error)	7.86	18	0.44			

(1) Calculated composite mean square and tested against composite valid error.
(2) Tested against the significant first order interaction (V x S).

The very high significance of the variety effect indicates that the weights of 1000-kernels differed significantly between varieties. The variety Montcalm produced heaviest seeds among

Table 32. Adjusted total of 1000-kernel weights in grams over all replications, for varieties, infection and seed categories from Experiment ii, a at Lacombe in 1959

Variety	Infection	Seed size: Large	Medium	Small	Bulk	Total
Parkland I	Non infected	111.39	110.73	109.16	110.25	441.53
	Infected (1.6%)	112.35	113.16	109.90	110.78	446.19
	Total	223.74	223.89	219.06	221.03	887.72
Parkland II	Non infected	111.43	112.22	109.77	111.29	444.71
	Infected (2.1%)	111.84	110.50	109.99	113.00	445.33
	Total	223.27	222.72	219.76	224.29	890.04
Montcalm	Non infected	117.83	117.38	117.78	116.77	469.76
	Infected (2.1%)	117.68	119.28	118.02	116.16	471.14
	Total	235.51	236.66	235.80	232.93	940.90
Gateway	Non infected	91.93	91.38	91.68	91.71	366.70
	Infected (2.0%)	90.16	93.93	93.71	91.49	369.29
	Total	182.09	185.31	185.39	183.20	735.99
Wolfe	Non infected	108.52	107.43	105.55	106.10	427.60
	Infected (1.5%)	108.19	105.90	105.14	107.28	426.51
	Total	216.71	213.33	210.69	213.38	854.11
Compana	Non infected	166.58	163.33	163.02	162.73	655.66
	Infected (1.3%)	161.50	155.18	153.64	158.84	629.16
	Total	328.08	318.51	316.66	321.57	1284.82
Herta	Non infected	115.06	114.35	114.98	113.80	458.19
	Infected (1.1%)	114.63	113.13	115.42	115.01	458.19
	Total	229.69	227.48	230.40	228.81	916.38
Total	Non infected	822.74	816.82	811.94	812.65	3264.15
	Infected	816.35	811.08	805.82	812.56	3245.81
	Total	1639.09	1627.90	1617.76	1625.21	6509.96

six-rowed varieties. The size of seeds had some effect on 1000-kernel weight but the variance due to seed size did not reach significance. The differences in 1000-kernel weights due to the use of infected and non-infected seeds were also non-significant.

2. Experiment ii, b

Data on 1000-kernel weight in grams, per individual plot, together with unadjusted and adjusted treatment means are given in Appendices 20 and 21 for each year of the study. The analyses of variance of these data are given in Appendix 22, together with the S.E. for differences between treatment means, the L.S.D. and the relative precision.

From the analyses of variance, the treatment effects were found to be very highly significant in both 1959 and 1960.

Adjusted totals of 1000-kernel weights in grams over all replications, for varieties and seed categories for each year are given in Table 34. The analysis of variance for data on 1000-kernel weights in grams taken over both years is given in Table 35.

The analysis of variance showed the significant differences in 1000-kernel weights for varieties and years, but the effect of seed size on 1000-kernel weight was not significant. There were no significant interactions in any combinations between varieties, seed sizes and years.

As shown in Table 34, the variety Nord produced significantly heavier 1000-kernel weights and Gateway the lightest kernels in both years.

Table 34. Adjusted total of 1000-kernel weights over all replications, for varieties and seed categories from Experiment ii, b at Lacombe in 1959 and 1960

		Seed Sizes				
Varieties	Years	Large	Medium	Small	Bulk	Total
Gateway	1959	94.24	99.35	101.31	97.19	392.09
	1960	84.59	83.94	92.72	79.26	340.51
	Total	178.83	183.29	194.03	176.45	732.60
Husky	1959	118.27	119.05	123.43	117.66	478.41
	1960	106.41	102.82	103.65	104.23	417.11
	Total	224.68	221.87	227.08	221.89	895.52
Parkland	1959	115.49	115.22	117.53	114.77	463.01
	1960	107.50	105.18	111.23	97.83	421.74
	Total	222.99	220.40	228.76	212.60	884.75
Olli	1959	97.44	97.41	96.70	100.20	391.75
	1960	87.71	87.04	83.33	86.79	344.87
	Total	185.15	184.45	180.03	186.99	736.62
Pirkka	1959	109.61	108.28	103.17	105.82	426.88
	1960	89.53	96.96	98.84	93.47	378.80
	Total	199.14	205.24	202.01	199.29	805.68
Wolfe	1959	106.27	110.76	110.49	110.44	437.96
	1960	101.90	102.88	93.16	101.39	399.33
	Total	208.17	213.64	203.65	211.83	837.29
O.A.C. 21	1959	113.50	112.76	111.16	113.88	451.30
	1960	97.05	98.01	105.40	102.77	403.23
	Total	210.55	210.77	216.56	216.65	854.53
Nord	1959	131.33	123.16	125.95	122.86	503.30
	1960	106.18	110.49	103.66	106.59	426.92
	Total	237.51	233.65	229.61	229.45	930.22
Fort	1959	115.52	113.68	113.27	112.63	455.10
	1960	92.78	92.93	99.07	96.09	380.87
	Total	208.30	206.61	212.34	208.72	835.97
Total	1959	1001.67	999.67	1003.01	995.45	3999.80
	1960	873.65	880.25	891.06	868.42	3513.38
	Total	1875.32	1879.92	1894.07	1863.87	7513.18

Table 35. Analysis of variance of 1959-1960 data on 1000-kernel weight from Experiment ii, b

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	2873.06	71				
Varieties	1525.65	8	190.71	47.44**	2.36	3.36
Seed sizes	8.67	3	2.89	<1		
Years	1095.39	1	1095.39	272.49**	4.26	7.82
V x S	81.63	24	3.40	<1		
V x Y	62.02	8	7.75	1.93	2.36	
S x Y	3.12	3	1.04	<1		
V x S x Y (error)	96.58	24	4.02			

3. Experiment ii, c

Data on 1000-kernel weights in grams obtained from the experiments, conducted at two locations for two years, are given in Appendices 23 and 24. The 1000-kernel weight in grams per plot and for treatment means are shown separately for each year and each location. The analyses of variance resulting from each experiment, together with the L.S.D. and C.V. are given at the bottom of the corresponding tables.

Analyses of variance indicate highly significant treatment effects for each of the experiments.

Total 1000-kernel weights in grams over all replications, for varieties, seed categories, and rates of seeding for each experiment are given separately in Tables 36 and 37. The partition of treatment effect into its components based on these totals are also given in the pertinent table for each experiment. The results of the analyses of variance for treatment components are summarized in Table 38.

Table 36. Total 1000-kernel weights over all replications, for varieties, seed categories and rates of seeding from Experiment ii, c at Lacombe in 1959 and 1960

		Rate of seeding						Rate of seeding			
Varieties	Sizes	I	II	III	Total	Varieties	Sizes	I	II	III	Total
Gateway	Large	145.39	130.48	130.50	406.37	Gateway	Large	120.08	111.82	105.98	337.88
	Medium	140.97	132.20	130.47	403.64		Medium	121.21	115.03	106.68	342.92
	Small	144.60	134.77	132.66	412.03		Small	123.30	113.65	105.21	342.16
	Total	430.96	397.45	393.63	1222.04		Total	364.59	340.50	317.87	1022.96
Husky	Large	165.59	157.27	150.49	473.35	Husky	Large	150.49	142.46	134.11	427.06
	Medium	170.79	161.27	155.09	487.15		Medium	155.63	139.47	133.53	428.63
	Small	173.44	163.37	159.55	496.36		Small	157.17	150.52	141.28	448.97
	Total	509.82	481.91	465.13	1456.86		Total	463.29	432.45	408.92	1304.66
Wolfe	Large	154.24	147.12	147.29	448.65	Wolfe	Large	137.58	130.18	123.71	391.47
	Medium	152.72	148.17	144.20	445.09		Medium	140.50	135.54	125.25	401.29
	Small	153.51	150.84	148.16	452.51		Small	138.42	137.21	133.03	408.66
	Total	460.47	446.13	439.65	1346.25		Total	416.50	402.93	381.99	1201.42
Total	Large	465.22	434.87	428.28	1328.37	Total	Large	408.15	384.46	363.80	1156.41
	Medium	464.48	441.64	429.76	1335.88		Medium	417.34	390.04	365.46	1172.84
	Small	471.55	448.98	440.37	1360.90		Small	418.89	401.38	379.52	1199.79
	Total	1401.25	1325.49	1298.41	4025.15		Total	1244.38	1175.88	1108.78	3529.04

Partition of treatment effects

Components	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%	1%
Total (treat.)	974.08	26			1448.63	26				
Varieties	766.69	2	383.35	54.99** (1)	1128.34	2	564.17	354.82**	4.46	8.65
Rate	157.86	2	78.93	19.34** (2)	255.39	2	127.69	80.31**	4.46	8.65
Linear	146.89	1	146.89	36.00**	255.38	1	255.38	160.62**	5.32	11.26
Quadr.	10.97	1	10.97	2.69	0.01	1	0.01	<1		
Size	16.11	2	8.06	2.78 (2)	26.65	2	13.33	8.38*	4.46	8.65
V x R	16.31	4	4.08	9.07**	9.88	4	2.47	1.55	3.84	
V x S	11.59	4	2.90	6.44*	11.87	4	2.96	1.86	3.84	
R x S	1.95	4	0.49	1.09	3.78	4	0.94	<1		
V x R x S (E.)	3.57	8	0.45		12.72	8	1.59			

(1) Composite mean square tested against composite valid error.
(2) Tested against the significant first order interactions (V x R, V x S).

Table 37. Total 1000-kernel weights over all replications, for varieties, seed categories and rates of seeding from Experiment ii, c at Edmonton 1959 and 1960

		Rate of seeding						Rate of seeding			
Varieties	Sizes	I	II	III	Total	Varieties	Sizes	I	II	III	Total
Gateway	Large	127.45	120.27	117.68	365.40	Gateway	Large	123.88	113.74	107.05	344.67
	Medium	126.28	114.76	112.79	353.83		Medium	122.25	108.25	106.73	337.23
	Small	134.65	115.32	110.97	360.94		Small	123.64	110.10	106.31	340.05
	Total	388.38	350.35	341.44	1080.17		Total	369.77	332.09	320.09	1021.95
Husky	Large	139.31	123.36	112.82	375.49	Husky	Large	132.24	110.77	110.00	353.01
	Medium	136.92	122.15	120.98	380.05		Medium	131.39	113.81	109.30	354.50
	Small	140.99	128.62	118.47	388.08		Small	135.05	121.83	113.10	369.98
	Total	417.22	374.13	352.27	1143.62		Total	398.68	346.41	332.40	1077.49
Wolfe	Large	133.61	126.43	123.43	383.47	Wolfe	Large	131.74	126.32	126.36	384.42
	Medium	140.66	129.17	126.00	395.83		Medium	137.56	120.14	121.62	379.32
	Small	146.38	127.97	124.95	399.30		Small	133.31	124.90	121.23	379.44
	Total	420.65	383.57	374.38	1178.60		Total	402.61	371.36	369.21	1143.18
Total	Large	400.37	370.06	353.93	1124.36	Total	Large	387.86	350.83	343.41	1082.10
	Medium	403.86	366.08	359.77	1129.71		Medium	391.20	342.20	337.65	1071.05
	Small	422.02	371.91	354.39	1148.32		Small	392.00	356.83	340.64	1089.47
	Total	1226.25	1108.05	1068.09	3402.39		Total	1171.06	1049.86	1021.70	3242.62

Partition of treatment effects

Components	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%	1%
Total (treat.)	583.81	26			616.63	26				
Varieties	138.32	2	69.16	29.18**	204.60	2	102.30	60.53**	4.46	8.65
Rate	375.77	2	187.89	79.28**	349.92	2	174.96	103.53**	4.46	8.65
Linear	347.42	1	347.42	146.59**	309.84	1	309.84	183.34**	5.32	11.26
Quadr.	28.34	1	28.34	11.96**	40.08	1	40.08	23.72**	5.32	11.26
Size	8.79	2	4.40	1.86	4.78	2	2.39	1.41	4.46	
V × R	9.85	4	2.46	1.04	23.70	4	5.92	3.50	3.84	
V × S	15.19	4	3.80	1.60	13.70	4	3.42	2.02	3.84	
R × S	16.96	4	4.24	1.79	6.42	4	1.61	<1		
V × R × S (E.)	18.93	8	2.37		13.51	8	1.69			

Table 38. Significance of main effects and interactions for 1000-kernel weight from Experiment ii, c

Source of variation	Lacombe 1959	Lacombe 1960	Edmonton 1959	Edmonton 1960
Treatments	**	**	**	**
Varieties	**	**	**	**
Rates	**	**	**	**
Linear	**	**	**	**
Quadratic	N.S.	N.S.	**	**
Seed sizes	N.S.	*	N.S.	N.S.
V x R	**	N.S.	N.S.	N.S.
V x S	*	N.S.	N.S.	N.S.
R x S	N.S.	N.S.	N.S.	N.S.

* Significant at the 5% level.

** Significant at the 1% level.

N.S. Non-significant ($P < 0.05$).

The results given in Table 38 show that the variations in 1000-kernel weight due to different varieties and to different rates of seeding were highly significant in each experiment at both locations and for both years. The linear effect of rates was also found to be highly significant. The quadratic effect, although non-significant in the Lacombe tests, was significant at Edmonton in 1959 and 1960. The highly significant linearity indicates that there was a progressive decline in the weight of 1000-kernels as the rate of seeding was increased. This decrease in 1000-kernel weight was not constant in Edmonton test, because of the deviation from the linearity (quadratic effect at the 1% level) was present under conditions of this experiment. The variation due to different seed

categories was significant at Lacombe only in 1960. However, the variation due to the size of seed used did not significantly exceed the uncontrolled variation but, as shown in Tables 36 and 37, there was a tendency for 1000-kernel weight to be less as the size of the seed sown increased. Significant interactions between varieties and rates of seeding and between varieties and seed sizes were found only in the Lacombe test for 1959.

Table 39 shows the combined analysis of the two years' data on 1000-kernel weights from Experiment ii, c conducted at the two locations.

Table 39. Analysis of variance of combined data on 1000-kernel weights from Experiment ii, c

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	7697.71	431				
Treatments	2829.07	26	108.81	3.92**(1)	1.84	2.39
Locations	1913.44	1	1913.44	72.02**(2)	4.23	7.22
Years	995.78	1	995.78	529.67**(2)	4.23	7.22
T × L	690.71	26	26.57	9.52**	1.46	1.70
T × Y	49.01	26	1.88	<1		
L × Y	261.87	1	261.87	93.86**	3.84	6.63
T × L × Y	54.36	26	2.09	<1		
Plot treated alike (3)	903.47	324	2.79			

(1) Calculated composite mean square tested against composite valid error.
(2) Tested against the significant first order interactions (T × L and L × Y).
(3) Represents a pooling of the S.S. and D.F. for all sources of variations involving replicates.

The results showed the F values for treatments, locations, years and the interactions between treatments and locations and between locations and years to be highly significant.

E. Yield

I. Experiment ii, a

Data on yield in grams per plot and unadjusted and adjusted treatment means are given in Appendix 25, together with the results of analysis of variance. The preliminary analysis showed a highly significant F value for treatments.

The adjusted total yields over all replications for seed categories and varieties grown from infected and non-infected seeds are given in Table 40. The results of the analysis for treatment components calculated from the adjusted totals are given in Table 41.

Table 41. Partition of treatment effect into its components

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total (treatments)	1207338.68	55				
Varieties	708065.80	6	118010.97	7.07**(1)	3.22	5.39
Sizes	292881.12	3	97627.04	24.45**(2)	3.16	5.09
Infection	21118.29	1	21118.29	1.63 (2)	4.41	
V x S	71847.90	18	3991.55	2.37*	2.27	3.23
V x I	77596.62	6	12932.77	7.68**	2.66	4.01
S x I	5523.42	3	1841.14	1.09	3.16	
V x S x I (error)	30305.47	18	1683.64			

(1) Calculated composite mean square and tested against the composite valid error.
(2) Tested against the significant first order interactions (V x S and V x I).

The results indicate highly significant differences in yield between varieties. The effect of seed size was also highly significant. The grain yield tended to increase with increasing

Table 40. Adjusted total yields over all replications, for varieties, infection and seed categories from Experiment ii, a at Lacombe in 1959

Varieties	Infection	Seed size: Large	Medium	Small	Bulk	Total
Parkland I	Non infected	1796.52	1539.44	1374.10	1663.45	6373.51
	Infected (1.6%)	1590.49	1466.97	1327.97	1503.54	5888.97
	Total	3387.01	3006.41	2702.07	3166.99	12262.48
Parkland II	Non infected	1689.59	1681.09	1393.75	1503.98	6268.41
	Infected (2.1%)	1553.86	1465.73	1302.35	1601.62	5923.56
	Total	3243.45	3146.82	2696.10	3105.60	12191.97
Montcalm	Non infected	1640.61	1425.09	1095.66	1223.14	5384.50
	Infected (2.1%)	1462.73	1346.19	962.60	1114.62	4886.14
	Total	3103.34	2771.28	2058.26	2337.76	10270.64
Gateway	Non infected	1454.39	1274.56	986.52	1307.76	5023.23
	Infected (2.0%)	1235.09	1198.32	1029.70	1128.38	4591.49
	Total	2689.48	2472.88	2016.22	2436.14	9614.72
Wolfe	Non infected	1887.02	1733.76	1408.52	1658.92	6688.22
	Infected (1.5%)	1822.88	1616.33	1352.71	1649.07	6440.99
	Total	3709.90	3350.09	2761.23	3307.99	13129.21
Compana	Non infected	1631.37	1468.12	1235.21	1296.46	5631.16
	Infected (1.3%)	1433.70	1224.96	996.37	1168.22	4823.25
	Total	3065.07	2693.08	2231.58	2464.68	10454.41
Herta	Non infected	857.46	1041.36	917.94	917.50	3734.26
	Infected (1.1%)	1223.01	1120.43	1014.72	1307.15	4665.31
	Total	2080.47	2161.79	1932.66	2224.65	8399.57
Total	Non infected	10956.96	10163.42	8411.70	9571.21	39103.29
	Infected	10321.76	9438.93	7986.42	9472.60	37219.71
	Total	21278.72	19602.35	16398.12	19043.81	76323.00

seed size in almost all varieties in both years, indicating that small seeds had less yielding capacity than medium and large seeds. The variance due to the use of infected and non-infected seeds did not reach significance when compared with the significant variety x infection mean square as valid error. However, the L.S.D. (1655.33 grams) at the 1% level indicated a significant difference between total yields resulting from infected and non-infected seeds. The significant interaction between variety and seed size indicates that the yielding ability of the varieties varied according to size of seed categories from which they were grown. Wolfe significantly outyielded the other six varieties for each seed category.

2. Experiment ii, b

Data on yield in grams per plot, together with unadjusted and adjusted treatment means are presented in Appendices 26 and 27, for each year of the study. The analyses of variance of these data are given in Appendix 28, together with the S.E. for differences between treatment means, the L.S.D. and the relative precision.

Highly significant treatment effects were present in both analyses. A slight increase (four per cent) in precision was found in 1959 and a much greater increase (59 per cent) in 1960.

Adjusted total yields in grams over all replications for varieties and seed categories for each year are given in Table 42. The results of analysis of variance for data on yield taken over both years are presented in Table 43.

Table 42. Adjusted total yields over all replications, for varieties and seed categories from Experiment ii, b at Lacombe in 1959 and 1960

Varieties	Years	Seed size: Large	Medium	Small	Bulk	Total
Gateway	1959	2894.42	2689.19	2634.87	2692.56	10911.04
	1960	2305.57	1969.89	1930.07	1963.45	8168.98
	Total	5199.99	4659.08	4564.94	4656.01	19080.02
Husky	1959	3438.14	3281.14	3300.16	3330.64	13350.08
	1960	2652.27	2338.31	2058.06	2206.25	9254.89
	Total	6090.41	5619.45	5358.22	5536.89	22604.97
Parkland	1959	3159.46	3046.44	3103.28	2921.42	12230.60
	1960	2475.33	1991.41	2217.60	1856.45	8540.79
	Total	5634.79	5037.85	5320.88	4777.87	20771.39
Olli	1959	2593.44	2571.73	2479.24	2550.76	10195.17
	1960	1995.12	1448.27	1597.95	1914.31	6955.65
	Total	4588.56	4020.00	4077.19	4465.07	17150.82
Prikka	1959	3001.66	2761.11	2678.50	2881.94	11323.21
	1960	1988.09	1906.48	1842.43	2061.08	7798.08
	Total	4989.75	4667.59	4520.93	4943.02	19121.29
Wolfe	1959	3636.30	3657.10	3464.45	3432.47	14190.32
	1960	2687.66	2180.91	1791.89	2209.02	8869.48
	Total	6323.96	5838.01	5256.34	5641.49	23059.80
O.A.C. 21	1959	2795.51	2661.37	2388.02	2705.81	10550.71
	1960	1972.04	1811.71	1794.39	2031.54	7609.68
	Total	4767.55	4473.08	4182.41	4737.35	18160.39
Nord	1959	2891.28	2711.11	2654.74	2775.07	11032.20
	1960	1817.48	1745.56	1635.20	1629.53	6827.77
	Total	4708.76	4456.67	4289.94	4404.60	17859.97
Fort	1959	2369.76	2235.80	2211.02	2246.09	9062.67
	1960	1758.52	1779.81	1661.86	1735.49	6935.68
	Total	4128.28	4015.61	3872.88	3981.58	15998.35
Total	1959	26779.97	25614.99	24914.28	25536.76	102846.00
	1960	19652.08	17172.35	16529.45	17607.12	70961.00
	Total	46432.05	42787.34	41443.73	43143.88	173807.00

Table 43. Analysis of variance of 1959-1960 data on yield from Experiment ii, b

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	7438564.9	71				
Varieties	1924801.4	8	240600.18	6.57**(1)	3.44	6.03
Seed sizes	249084.4	3	83028.13	17.59**	3.01	4.72
Years	4706727.9	1	4706727.90	128.62**(1)	5.32	11.26
V x S	131429.1	24	5426.21	1.16	1.98	
V x Y	292752.0	8	36594.00	7.75**	2.36	3.36
S x Y	20489.3	3	6829.77	1.45	3.01	
V x S x Y (error)	113280.8	24	4720.03			

(1) Tested against the significant first order interaction (V x Y).

From the resulting analysis, highly significant effects were observed for varieties, seed sizes and years. A highly significant interaction between varieties and years was present. The yielding ability was higher for all varieties in 1959 than in 1960 and considerably greater differences in yield were demonstrated between varieties. Comparisons of varietal yields over all seed categories show highly significant differences, while the interaction between variety and size of seed failed to demonstrate significant differences. In general, there was a striking relation between size of seeds sown and resulting yield; the yield of grain for all varieties, tended to be greater as larger seeds were used.

On the basis of the average yield of varieties, the comparison of the relative yield resulting from the large, medium and small seed fractions with bulk seed is given in Table 44.

Table 44. Yields of the three seed fractions compared with yields from bulk seeds (bulk = 100)

Varieties	Seed sizes: Large	Medium	Small
Gateway	111.68	100.07	98.04
Husky	110.00	101.49	96.77
Parkland	117.94	105.44	111.36
Olli	102.76	90.03	91.31
Pirkka	100.95	94.43	91.46
Wolfe	112.10	103.48	93.17
O.A.C. 21	100.64	94.42	88.29
Nord	106.91	101.18	97.40
Fort	103.68	100.85	97.27
Average	107.41	99.04	96.12

On the average, the yield from large seeds was superior by 7.41 per cent to the bulk seed, while the yield from small seeds was 3.88 per cent inferior. The result for each variety indicates a distinct advantage for the large as compared with the ungraded bulk seed. This advantage was especially striking in Wolfe, Gateway and Husky. Parkland gave an exceptional result in that the small seeds yielded more than the bulk and medium sized seeds in each year.

On the basis of total yields for all seed sizes, Wolfe and Husky differed significantly from the others. The differences in yield resulting from different seed size categories were negligible between Wolfe and Husky as compared with the other varieties.

3. Experiment ii, c

Yield data from experiments conducted at Lacombe and Edmonton in 1959 and 1960 are given in Appendices 29 and 30. Yield in grams per plot and treatment means are shown for each location and each year separately. The analyses of variance resulting from each experiment, together with the L.S.D. and C.V. are also given at the bottom of the corresponding tables.

Analyses of variance indicate highly significant treatment effects for each of the experiments.

Total yields in grams over all replications, for varieties, seed categories and rates of seeding for each experiment are given separately in Tables 45 and 46. The partitions of treatment effects into its components based on the total data of Table 45 and 46 are given in the pertinent table for each experiment. Significance of main effects and interactions obtained from the analysis of treatment components are summarized in Table 47.

Table 45. Total yields in grams over all replications, for varieties, seed categories and rates of seeding from Experiment ii, c at Lacombe in 1959 and 1960

		Rate of seeding			
Varieties	Sizes	I	II	III	Total
Gateway	Large	3206	3415	3554	10175
	Medium	2794	3273	3678	9745
	Small	2974	3387	3261	9622
	Total	8974	10075	10493	29542
Husky	Large	3782	4168	4629	12579
	Medium	4139	4068	4361	12568
	Small	3145	4052	4630	11827
	Total	11066	12288	13620	36974
Wolfe	Large	3948	4537	4534	13019
	Medium	3625	4165	4541	12331
	Small	3269	4009	4448	11726
	Total	10842	12711	13523	37076
Total	Large	10936	12120	12717	35773
	Medium	10558	11506	12580	34644
	Small	9388	11448	12339	33175
	Total	30882	35074	37636	103592

		Rate of seeding			
Varieties	Sizes	I	II	III	Total
Gateway	Large	2374	2462	2813	7649
	Medium	2014	2301	2481	6796
	Small	1925	2217	2250	6392
	Total	6313	6980	7544	20837
Husky	Large	3027	3260	3401	9688
	Medium	2969	3061	3219	9249
	Small	2360	2856	3111	8327
	Total	8356	9177	9731	27264
Wolfe	Large	2472	2952	3126	8550
	Medium	2210	2640	2915	7765
	Small	2005	2358	2837	7200
	Total	6687	7950	8878	23515
Total	Large	7873	8674	9340	25887
	Medium	7193	8002	8615	23810
	Small	6290	7431	8198	21919
	Total	21356	24107	26153	71616

Partition of treatment effects

Components	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%	1%
Total (treat.)	2010333.8	26			1181819.2	26				
Varieties	1037094.3	2	518547.15	33.08**	579009.4	2	289504.70	88.83**	4.46	8.65
Rate	645863.1	2	322931.55	20.60**	321901.2	2	160950.60	49.38**	4.46	8.65
Linear	633562.7	1	633562.70	40.42**	319600.1	1	319600.12	98.06**	5.32	11.26
Quadr.	12300.4	1	12300.40	<1	2301.1	1	2301.05	<1		
Size	94279.6	2	47139.80	3.01	218841.0	2	109420.50	33.57**	4.46	8.65
V x R	43719.5	4	10929.88	<1	22731.1	4	5682.77	1.74	3.84	
V x S	20491.5	4	5122.88	<1	6824.3	4	1706.07	<1		
R x S	43491.7	4	10872.93	<1	6438.2	4	1609.54	<1		
V x R x S (E.)	125394.1	8	15674.26		26074.0	8	3259.25			

Table 46. Total yields in grams over all replications, for varieties, seed categories and rates of seeding from Experiment ii, c at Edmonton in 1959 and 1960

Varieties	Sizes	Rate of seeding I	II	III	Total
Gateway	Large	3395	3960	4300	11655
	Medium	3375	3590	3980	11305
	Small	3315	3654	3355	10324
	Total	10085	11564	11635	33284
Husky	Large	4392	4515	4515	13422
	Medium	4170	4215	4557	12942
	Small	3299	4615	4300	12214
	Total	11861	13345	13372	38578
Wolfe	Large	3890	4485	4470	12845
	Medium	4005	4741	4435	13181
	Small	3770	4265	4865	12900
	Total	11655	13491	13770	38926
Total	Large	11677	12960	13285	37922
	Medium	11550	12906	12972	37428
	Small	10384	12534	12520	35438
	Total	33611	38400	38777	110788

Varieties	Sizes	Rate of seeding I	II	III	Total
Gateway	Large	3890	4353	4388	12631
	Medium	3697	4247	4212	12156
	Small	3712	4270	4152	12134
	Total	11299	12870	12752	36921
Husky	Large	4675	4721	4962	14358
	Medium	4605	4660	4783	14048
	Small	4202	4460	4478	13140
	Total	13482	13841	14223	41546
Wolfe	Large	4575	5292	4952	14819
	Medium	4207	4825	4912	13944
	Small	2315	3602	3835	9752
	Total	11097	13719	13699	38515
Total	Large	13140	14366	14302	41808
	Medium	12509	13732	13907	40148
	Small	10229	12332	12465	35026
	Total	35878	40430	40674	116982

Partition of treatment effects

Components	S.S.	D.F.	M.S.	F.	S. S.	D.F.	M.S.	F.	5%	1%
Total (treat.)	1418812.9	26			2239682.1	26				
Varieties	555368.2	2	277684.10	9.96**	306652.1	2	153326.05	1.01 (1)	6.94	
Rate	460780.2	2	230390.10	8.26*	405387.6	2	202693.80	23.81**	4.46	8.65
Linear	370660.0	1	370660.05	13.29**	319466.9	1	319466.89	37.52**	5.32	11.26
Quadr.	90119.2	1	90119.18	3.23	85920.7	1	85920.67	10.09*	5.32	11.26
Size	96059.7	2	48029.85	1.72	694314.9	2	347157.45	2.28 (1)	6.94	
V x R	9337.3	4	2259.33	<1	124133.2	4	31033.30	3.65	3.84	
V x S	50355.6	4	12588.90	<1	608190.2	4	152047.55	17.86**	3.84	7.01
R x S	23760.6	4	5940.15	<1	32894.9	4	8223.73	<1		
V x R x S (E.)	223151.3	8	27893.91		68109.2	8	8513.65			

(1) Tested against the significant first order interaction (V x S).

Table 47. Significance of main effects and interactions for yield from Experiment ii, c

Source of variation	Lacombe 1959	Lacombe 1960	Edmonton 1959	Edmonton 1960
Treatments	**	**	**	**
Varieties	**	**	**	N.S.
Rates	**	**	*	**
Linear	**	**	**	**
Quadratic	N.S.	N.S.	N.S.	*
Seed sizes	N.S.	**	N.S.	N.S.
V × R	N.S.	N.S.	N.S.	N.S.
V × S	N.S.	N.S.	N.S.	**
R × S	N.S.	N.S.	N.S.	N.S.

* Significant at the 5% level.
** Significant at the 1% level.
N.S. Non-significant ($P \not< 0.05$).

This analysis shows that the differences in yield between varieties were highly significant at Lacombe in both years and in Edmonton in 1959. There was no apparent significant difference in yield between varieties at Edmonton in 1960, when the significant variety × seed size interaction was used as valid error in testing significance for varieties. However, when the comparison based on the L.S.D. (1860.17 grams) at the 5% level for differences between paired variety totals indicate the existence of significant differences between varieties. The main effect of rate of seeding was found to be highly significant in each of the experiments. There was a highly significant linearity in the effect of rate of seeding. The yield increased in a linear manner with increased rate of seeding in each year except the Edmonton test in 1960. A significant quadratic effect (at the 5% level) was present in this test. This indicates

that the increase in yield due to the increase in rate of seeding was not constant in the Edmonton test in 1960. However, the progressive increments of yield as a straight line association with increase in rates of seeding within varieties and within seed categories were detected when each variety and each seed category was considered as a separate experiment and analyzed individually, using the data of Tables 45 and 46. The variation due to different seed sizes used was significant only in the Lacombe test in 1960.

In general, the results of analyses of variance did not show significant interaction in any combination of variety, seed size and rate of seeding except one, the interaction between variety and seed size was found to be highly significant in the Edmonton test in 1960.

Standard errors and L.S.D. in grams, with respect to the total yields resulting from different seed categories within varieties and over all varieties are given in Table 48.

Table 48. Standard errors and L.S.D. in grams (at the 5% level) for total yields resulting from seed categories within varieties and over all varieties from Experiment ii, c

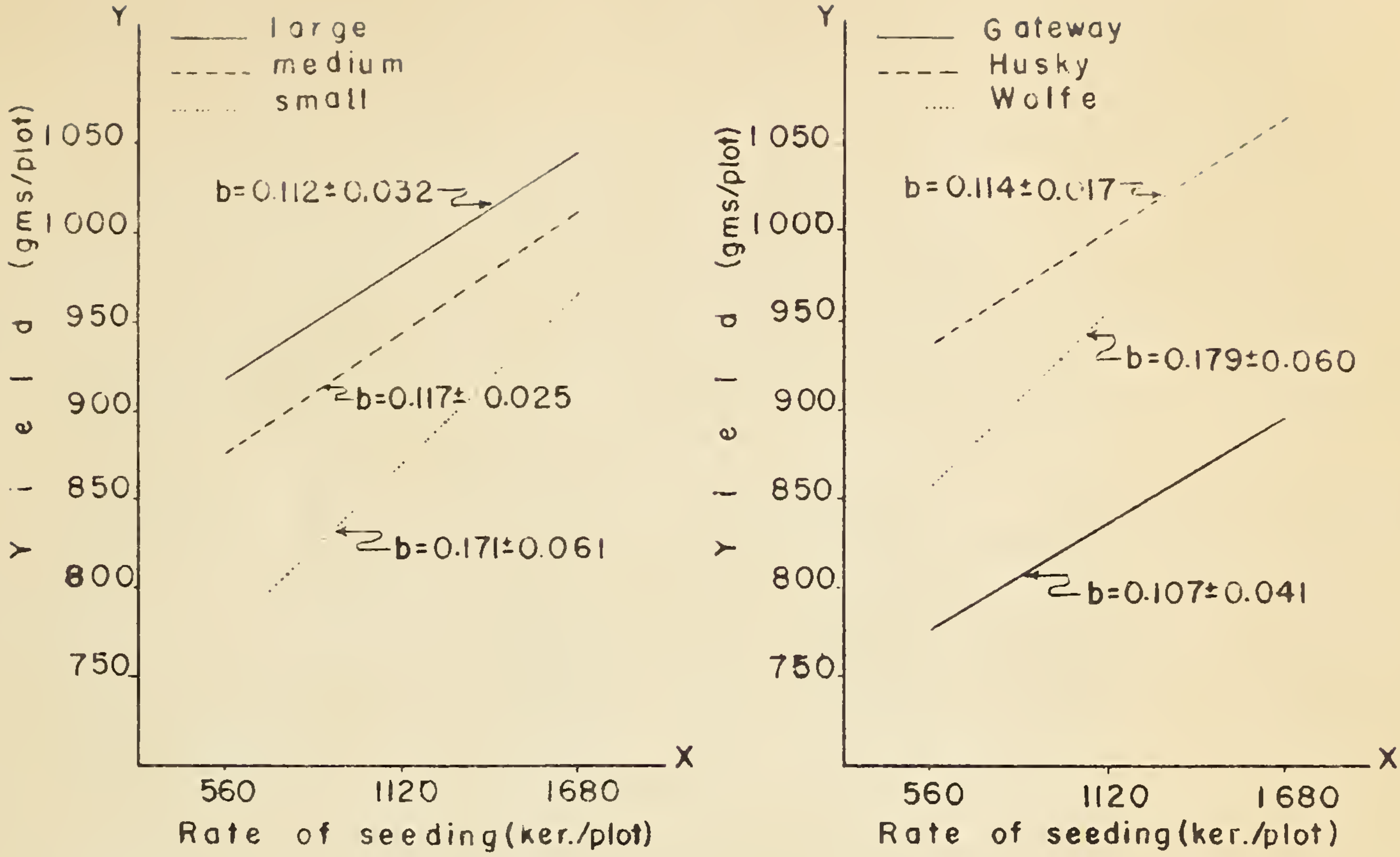
	Within varieties		Over all varieties	
	S.E. ($\pm$)	L.S.D.	S.E. ($\pm$)	L.S.D.
Lacombe				
1959	397.67	1119.18	688.80	1938.46
1960	230.62	649.04	399.45	1124.17
Edmonton				
1959	426.40	1312.58	807.83	2273.45
1960	381.60	1073.96	660.98	1860.17

The comparison based on the L.S.D. indicates that in some varieties there were significant differences in yield resulting from large and small seeds. This difference was also observed between totals over all varieties. In some instances the yield resulting from large and medium seeds and from medium and small seeds did not give necessary differences for significance at the 5% level. However, in most instances there was a strong and fairly consistent tendency towards production of higher yields as larger seeds were used.

The graphical analyses, as shown in Figure 3, support the previously indicated evidence of differential response of different seed sizes and varieties to the rate of seeding.

It is clear from the regression lines and the values of regression coefficient that the response of yield production to different rates of seeding was slightly higher in small sized seeds than the other two categories. Large and medium seeds were found to be more or less similar in response. Over all varieties and rates of seeding, the large seed yielded 3.9 per cent more grain than medium and 12.6 per cent more grain than small seeds. Medium sized seed yielded 8.3 per cent more grain than small seed.

The results of variety yields over all seed categories indicate a distinct advantage for the heavy rate (1680 ker./plot) as compared with the light rate (560 ker./plot). The yield from heavy rate was 17.7 per cent superior to the light rate, while superiority over medium rate (1120 ker./plot) was only 3.8 per cent. The yield from the medium rate of seeding was 13.4 per cent superior



Size	R.I	R.II	R.III
Large	909	1003	1034
Medium	871	961	1002
Small	756	911	948

Variety	R.I	R.II	R.III
Gateway	764	864	884
Husky	933	1014	1061
Wolfe	839	997	1039

Figure 3. Yield per plot; linear regression of the differences in response to the rate of seeding within seed categories and within varieties, respectively.

to the light rate. This advantage was the greatest for Wolfe. As shown in Figure 3, Wolfe showed slightly more response to the increased seeding rate than others. This behaviour was consistent at two locations. It is also clear from the graph that Husky produced the highest yield at the heavy rate from the large seed.

Table 49 shows the analysis of two-year combined data on yield from experiments conducted at two locations.

Table 49. Analysis of variance of combined data on yield from Experiment ii, c

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	22295246.0	431				
Treatments	5322305.6	26	204704.06	5.23* (1)	1.65	2.03
Locations	6395286.7	1	6395286.70	1.90 (2)	161.04	
Years	1538684.2	1	1538684.20	53.58**(2)	4.23	7.72
T x L	334967.7	26	12883.37	1.01	1.46	
T x Y	746629.2	26	28716.51	2.25**	1.46	1.70
L x Y	3372566.8	1	3372566.80	264.08**	3.84	6.63
T x L x Y	446944.8	26	17190.18	1.35	1.46	
Plots treated alike (3)	4137861.0	324	12771.17			

(1) Composite mean square and tested against composite valid error.
(2) Tested against the significant first order interactions (L x Y and T x Y).
(3) Represents a pooling of the S.S. and D.F. for all sources of variations involving replicates.

The analysis indicates that the differences in yield due to locations were not significant when the significant L x Y interaction was used as the criterion. Treatments and years effects were found to be highly significant. The interactions between treatments and years and between locations and years were found to be highly significant. The T x L and T x L x Y interactions did not reach the 0.05 significance point.

V. GENERAL DISCUSSION AND CONCLUSION

i. The incidence of loose smut

It was found that the sizes of seeds were closely related to their relative position in the six-rowed spike, the larger seeds being formed in the central rows and in the middle and lower parts of the spike, while the smaller ones were formed in the lateral rows and in the upper part of the spike. These results are in agreement with those of other workers (1, 20). The differences in size between the seeds from the above mentioned parts of the spike are considered great enough to provide a differential for experimental studies.

The results from experiments on the incidence of loose smut infection, in relation to the sizes of seeds borne in different parts of the spike, gave very strong indication that seed size is intimately related to loose-smut infection in barley.

However, this relation was not always apparent in material derived from artificial inoculations made by hand or partial vacuum methods. For example, Titan and Newal exhibited approximately an equal amount of loose smut development from the seeds derived from central and lateral florets. This was probably due to forcible entry of the spores into the flowers. However, in the greenhouse test made with Gateway, 6.9 per cent more smut infection was present in plants from smaller seeds developed from lateral florets. It was also observed in cases of artificial inoculation in Titan and Newal that smut infection differed in the plants grown from seeds developed

at the upper, middle and lower parts of the spike, infection being higher, intermediate and lower in these parts, respectively. The reverse was true in the variety Gateway, in which a slightly higher infection occurred in the stands derived from seeds of the lower part of the spike. It should be emphasized here that the seeds of Newal from the 1938 supply produced as much smut infection as the newly inoculated seeds of the same variety. This no doubt resulted from the prolonged survival of mycelium of Ustilago nuda within the seed (5). In this case, the mycelium within the seed evidently remained viable for 22 years. The germination test under field conditions in 1960, as shown in Table 4, indicates that the seeds still possess high germinability and that they contain sufficient viable mycelium inside to produce high amounts of infection.

In the case of natural infection, besides the genetic factors and environmental conditions, the development of the florets on different parts of the spike may be expected generally to play a major role in the degree of infection. Reference to Table 6 and 7 will serve to show how seed sizes, resulting from the position of the florets in the spike, are associated with the degree of infection. Higher percentages of infection were present in stands grown from small seeds developed from lateral florets. This result agrees with those of Taylor and Harlan (35) in indicating that the incidence of smut is much greater in plants from lateral kernels than in those from central kernels.

The greater infection in the lateral florets may be due to their slower development. The longer optimum period (30) together with the more open lateral florets allows greater opportunity for infection. This conclusion is in agreement with the conclusion of Taylor and Harlan (35).

The data from the field experiment made with six varieties indicate that, in general, the average smut percentage in plants grown from lateral kernels is approximately double that found in the plants grown from central kernels.

In the greenhouse test made with three different samples of the variety York, as shown in Table 9, there were much greater differences in production of smutted heads. The plants grown from seeds of lateral florets produced 2.5, 3.4 and 4.8 times as many smutted heads as those grown from seeds of central florets (in the samples grown from small, medium and large seeds, respectively). Further, the size of seed of the previous generation seems to influence the incidence of smut infection. Seeds from plants which were originally grown from small seeds produced plants which showed higher smut infection for both lateral and central kernels. As it has already been mentioned, the smaller lateral kernels carried more smut infection because the lateral florets, remaining open longer during the flowering period, are liable to be more smut infected. Influence of size of seeds sown on the incidence of smut infection on the plants of second generation may be explained on the assumption that the sample of smaller seeds included relatively more infected seeds and hence when these seeds were grown, relatively more infected

heads would be produced, which in turn would favour the chances of floral inoculation to the surrounding plants. Therefore, this high amount of spores may cause heavy infection on lateral florets and also may cause rather heavy infection on central florets for next generation. It could also be considered as a supplementary reason for more infection in the subsequent crop from small seeds because plants grown from small seeds do not head as soon as those grown from large seeds (Kaufmann and McFadden , 19), and more liable to infection during their flowering period. Plants grown from large seeds would sometimes flower before high amounts of spores were produced mostly by the plants grown from small seeds. Therefore, the chance of floral inoculation would be reduced in plants grown from large seeds and eventually less infection would occur in succeeding generations of these plants as compared with those from small seeds.

The question now arises, is there any possibility that loose smut infection itself produces a slight reduction in kernel size and weight? Taylor (34) observed higher amounts of loose smut in the plots seeded with small seeds and he concluded the presence of loose-smut organisms may check the development of the endosperm of the wheat kernel thus causing a slight reduction in kernel size and weight. The present study cannot fully support the conclusion drawn by Taylor because the highest percentage of smut was observed in plants from seeds which were developed in the lateral florets on the spike. The measurement of the size of seed in terms of 1000-kernel weight indicated that the seeds from lateral florets are in

general much smaller than seeds from central florets. This is in agreement with other studies (1, 20). It does not, however, mean that the invading mycelium causes a reduction in size or weight of the developing kernel. While it might be possible that the seed size could be affected by the invading mycelium, the more probable cause is the relative position of the florets on the spike.

Plants from the seeds developed at the lower, middle and upper portions of the spike exhibited considerable variation in degree of infection. This variation was not the same with each variety. On the whole, the plants grown from seeds developed from both the central and lateral florets of the middle part of the spike, showed less smut infection than those from upper and lower parts.

The general conclusion to be drawn from these experiments is that, under natural conditions, the positions of the florets on the spike play important roles in determining whether they become infected with loose smut, the most important relation being that small-sized seeds from lateral florets tend to carry more loose smut infection than larger seeds from central florets.

The knowledge that infection with loose smut is encouraged by the more open and slower developing lateral florets, which give rise to smaller seeds in barley, may be useful to seed growers, farmers and research workers. In practice, therefore, removal of the small seeds from the stock by using appropriate seed cleaners would reduce the incidence of loose smut in the current crop as well as in subsequent generations. Consequently, the practice would result in better yield.

ii. The effect of seed size on characters studied

A. Number of seedlings

In one experiment (Experiment ii, a) it was found that larger seed produced greater numbers of seedlings than smaller seeds, while in all other experiments, the results appeared to be contradictory. In general it may therefore be concluded that the seed size has no consistent effect on the numbers of seedlings established.

Inclusion of infected seeds in the experiment did not produce a significant effect on the stand establishment. This may be due to very low percentage of infected seeds included.

There was some indication of differences in seedling production among the varieties but the variability within them in two years' experiments emphasized the lack of consistency.

Rate of seeding was the main determinant of number of seedlings, indicating an increase in number of seedlings with increases in rates of seeding for each seed category and each variety. This agrees with the results of Thayer and Rather (36) in indicating that with the increased rate of seeding the number of plants per unit area increased, and also with those of Guitard _et al_. (11), who considered that the number of plants per acre was a direct, positive, linear function of seeding rate.

B. Number of culms

It is clear from the present results that number of culms per plot was greatly affected by the size of seeds sown. The number of culms tended to increase with increasing seed size in all varieties. This finding coincides with the results of Bonnet and Woodworth (4) and Kaufmann (18) in confirming that plants from large seeds produce a larger number of tillers than plants from small seeds.

Differences in number of culms resulting from infected and non-infected seeds over all seed sizes were rather small. Non-infected seeds of six-rowed varieties showed a slight advantage over infected seeds but the reverse was found in two-rowed varieties in which more culms were produced by seeds considered to be infected. This could have resulted from the fact that the seeds were obtained from different sources.

Great varietal differences in number of culms were expressed in each experiment for each year. However, the results were very inconsistent for all varieties except Gateway, which consistently produced more tillers than the other six-rowed varieties. Two-rowed varieties as a group produced higher numbers of culms than six-rowed varieties.

Variation in rates of seeding had marked effects on number of culms in each location over both years. The significant linear relation shown in the analyses indicates a progressive increase in the number of culms per plot in each seed category as rate of seeding was increased. The results are similar to those of Sprague and Farris (32) who found that the total number of fertile culms per foot section

(foot of row) was greater for the heavier rate of seeding. Increased rate of seeding in small seeds produced relatively more culms as compared to those of the other two categories.

C. <u>Number of smutted heads</u>

Larger numbers of smutted heads developed in plants resulting from small seeds than those from larger seeds. This is in close agreement with the results reported in the first part of the study, and also with the results of McFadden <u>et al</u>. (23), indicating that small and medium sized seeds carried more smut than large seeds.

In general, percentage infection was high in plants grown from artificially-inoculated, smaller seeds for all varieties used in Experiment ii, a, except Gateway and Parkland. The plants of these two varieties produced higher smut infection from seeds considered as non-infected. The possible explanation of this is that Gateway and Parkland had been greatly influenced by the natural infection of loose smut in previous year and their seeds, taken to be non-infected, were already carrying more smut infection than artificially inoculated ones.

Rates of seeding had no effect on the percentage of smutted heads in any combination with seed sizes. This result in in agreement with Milan (24) who concluded, in part, that the rate of sowing exercised virtually no effect on the percentage of the plants that became diseased. Regarding these results only the infected seeds

produce diseased plants and, as the percentage of infected seeds included in the seed lot is fixed, no change is to be expected in the percentage of diseased plants and heads with the change in rate of seeding.

D. 1000-kernel weight

The 1000-kernel weights for resulting plants, as influenced by the size of seeds sown, did not follow any recognizable pattern.

However, 1000-kernel weights were greatly influenced by rate of seeding. The 1000-kernel weights decreased for all three varieties and each seed category as rate of seeding was increased. The decrease was linear in the Lacombe tests. Guitard *et al.* (11), from their studies in barley reported the reduction in 1000-kernel weight with increasing rate of seeding.

E. Yield

It may be concluded from the foregoing that seed size has a marked influence on some characters related to yield and consequently on the grain yield itself. Indeed the experimental results on yield showed a striking relation between size of seed sown and resulting yield. The use of large seeds in Experiments ii a, b, resulted in higher yield when seeds were sown in equal numbers at a rate optimum for the large seeds, a result in agreement with those of other workers (2, 19, 21, 37).

Analyses of variance for treatment components from Experiment ii, c did not show significant effect for seed sizes (as shown in Table 47) except the Lacombe test in 1960. However, the comparisons based on the L.S.D. indicate that in some varieties there were significant differences in yield resulting from large and small seeds. Moreover, in most cases there was a strong and fairly consistent tendency towards higher yields as larger seeds were used.

The variation in yield due to inoculated and non-inoculated seeds was not significant when the significant first order interaction (V x I) was used as error in testing significance. It should be pointed out that the expected reduction in yield from infected seeds on the assumption of "yield losses in barley to be approximately as great as percentage of loose smut infection" (7, 31), may easily fall in coefficient of variability which was found in the experiment. However, when L.S.D. was used to test significance it was found that there are significant differences between total yields resulting from inoculated and non-inoculated seeds. These differences may be partly due to the source of the seeds since the inoculated lot was obtained from Saskatoon, Saskatchewan, and the non-inoculated from Lacombe.

Yield of grain in grams per plot was also significantly modified by rates of seeding showing a linear increase with increasing the rate of seeding in three of four tests. Further, the same relations were detected within seed categories and within varieties

when each category and variety was analyzed individually as a separate experiment. These results are in agreement with those of other workers (3, 10, 22, 27, 38).

The increases in yield from heavy rate (1680 ker./plot) as compared with light rate (560 ker./plot) was 17.7 per cent. The increases in yield from heavy rate as compared with medium rate (1160 ker./plot) was only 3.8 per cent. This indicates quite clearly that increased yield from sowing much more than the optimum rate (which is around 1200 ker./plot for the region in which experiments were done) was rather small. These results are similar to those of others (8, 11, 13, 26, 32) in indicating small further increase from the heavier rates over optimum ones.

On the whole, the following conclusions may be drawn from the second part of the study:

(a) Number of seedlings per unit area did not show significant improvement as size of seed sown was increased. The seeding rate, as expected, was the main determinant of number of seedlings.

(b) Number of culms per plot tended to increase with increasing seed size indicating that small seeds were less able to produce tillering than medium and large seeds. Rate of seeding tests indicate a progressive increase in the number of culms as the rate of seeding was increased.

(c) Number of smutted heads agreed with the results of the first part, the larger number of smutted heads occurring in plants resulting from small seeds.

(d) The 1000-kernel weight in the resulting plant was influenced to some extent by the size of seed sown, but the trend was not consistent. This character was also influenced by rates of seeding, the weight being decreased as rate of seeding was increased.

(e) Yield of grain for all varieties tended to be greater as larger seeds were used. Yield was also significantly modified by the rates of seeding, the increase being relatively high and linear until optimum rate was reached after which it dropped off.

(f) Yield of grain was negatively associated with 1000-kernel weight in each size and variety. This association did not appear to be an important consideration in determining yield (17).

(g) Yield of grain was closely related to number of seedlings and number of culms produced per plot.

(h) Results of this study emphasize that research workers should take into consideration the size of seed used in yield trials in barley, and perhaps in any short-lived crop, because the difference in size of seeds used may itself create differences in vigor and yield.

VI. SUMMARY

The relation of seed size to loose smut (*Ustilago nuda* (Jens.) Rostr.) infection and yield in barley (*Hordeum vulgare* L.) was studied in two main experiments.

(i) The first was on the incidence of loose smut infection and its relation to the size of the seed, borne on different parts of the spike. The seeds used for this study were obtained from central-row and lateral-row florets of the lower-third, middle-third and upper-third parts of the spikes which had been exposed to natural infection in the previous year. Artificially inoculated seeds were also used.

1. Artificial inoculation resulted in practically an equal amount of loose-smut development for the seeds derived from central and lateral florets of different parts of the spike.

2. In the case of natural infection, the position of the florets on different parts of the spike generally played an important role in the degree of infection. The most important relation was small-sized seeds from lateral florets which tend to carry more loose smut infection than larger seeds from central florets.

(ii) The second experiment was on the effect of seed size on some characters related to yield. The grain yield was determined together with the components: number of seedlings, number of culms, number of loose smutted heads and 1000-kernel weight. Several barley

varieties tested for this purpose were of the following categories:
(a) infected and non-infected large, medium, small and bulk seeds;
(b) non-inoculated large, medium, small and bulk seeds; and
(c) non-inoculated large, medium and small seeds sown at different rates.

1. Number of seedlings per plot did not show significant improvement as size of seed sown was increased. The rate of seeding was the main determinant of number of seedlings indicating an increase in number of seedlings with increasing rate of seeding.

2. Number of culms per plot was greatly affected by the size of seeds sown. The number of culms tended to increase with increasing seed size in all varieties, indicating that small seeds were less able to produce tillers than medium and large seeds. The rate-of-seeding tests indicate a progressive increase in the number of culms in all seed categories as the rate of seeding was increased.

3. The results obtained on the number of smutted heads were in agreement with the results obtained in the first experiment. Again larger numbers of smutted heads were found in plants resulting from small and medium sized seeds. Rates of seeding had no effect on percentage of smutted heads in any combination with seed sizes.

4. The 1000-kernel weight was influenced to some extent by the size of the seeds used to produce the plant, but the trend was not consistent. The 1000-kernel weight was greatly influenced by rates of seeding, the weight being decreased for all varieties as rate of seeding was increased.

5. The results showed a striking relation between size of seed sown and resulting yield. Yield of grain for all varieties tended to be greater as larger seeds were used. On the average, yields from large seeds were 7.41 per cent higher than that from bulk seed, while yield from small seed was 3.88 per cent lower than that from bulk seed. Yield in grams per plot was also significantly modified by the rates of seeding, showing linear increases with increasing the rate of seeding. The yield from heavy rate was 17.7 per cent superior to the light rate, while superiority over medium was only 3.8 per cent. The yield from medium rate was 13.4 per cent superior to the light rate of seeding. Seeding rates beyond the optimum gave yields that dropped progressively below linear rates of increase.

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VIII. APPENDICES

Appendix I. Data on number of seedlings per plot and unadjusted, adjusted treatment means, together with the results of analysis of variance from Experiment ii, a at Lacombe in 1959

Treatments			Replications			Average	
			X	Y	Z	Unadj.	Adj.
Park. I	non inf.	lar.	267	263	267	265.67	265.80
		med.	271	272	251	264.67	264.67
		sm.	270	257	258	261.67	261.60
		bulk	273	246	258	259.00	258.72
Park. I	inf.	lar.	271	269	269	269.67	269.49
		med.	264	254	263	260.33	260.41
		sm.	245	233	251	243.00	242.90
		bulk	267	264	252	261.00	260.87
Park. II	non inf.	lar.	256	250	241	249.00	249.05
		med.	259	265	271	265.00	265.05
		sm.	261	262	247	256.67	256.53
		bulk	265	262	259	262.00	262.08
Park. II	inf.	lar.	256	271	249	258.67	258.60
		med.	260	268	257	261.67	261.66
		sm.	269	261	261	263.67	263.73
		bulk	258	261	255	259.00	257.73
Mont.	non inf.	lar.	270	257	261	262.67	262.56
		med.	279	269	255	267.67	267.38
		sm.	260	272	252	261.33	261.13
		bulk	263	264	282	269.67	269.54
Mont.	inf.	lar.	271	269	263	267.67	267.78
		med.	265	262	269	265.33	265.39
		sm.	277	261	242	260.00	260.14
		bulk	264	273	269	268.67	268.61
Gate.	non inf.	lar.	263	269	273	268.33	268.46
		med.	266	275	260	267.00	267.00
		sm.	251	265	254	256.67	256.68
		bulk	272	273	269	271.33	271.31
Gate.	inf.	lar.	241	235	258	244.67	244.74
		med.	258	226	235	239.67	259.69
		sm.	234	226	247	235.67	235.31
		bulk	226	243	231	233.33	233.72
Wolfe	non inf.	lar.	275	258	257	263.33	263.38
		med.	261	259	268	262.67	262.63
		sm.	253	261	257	257.00	257.19
		bulk	265	262	281	269.33	269.11
Wolfe	inf.	lar.	284	251	260	265.00	265.20
		med.	260	268	251	259.67	259.69
		sm.	248	248	256	250.67	250.76
		bulk	267	257	249	257.67	257.48

* The terms "non inf." and "inf." have been used in these appendices to describe artificially non-inoculated and inoculated seeds, respectively.

Appendix I. (continued)

Treatments			Replications X	Y	Z	Average Unadj.	Adj.
Comp.	non inf.	lar.	252	245	231	242.67	242.86
		med.	243	239	238	240.00	239.79
		sm.	219	224	235	226.00	226.39
		bulk	218	239	244	233.67	233.66
Comp.	inf.	lar.	246	265	254	255.00	254.67
		med.	260	276	263	266.33	266.51
		sm.	252	256	247	251.67	251.70
		bulk	288	270	262	273.33	273.32
Herta	non inf.	lar.	257	261	268	262.00	262.25
		med.	270	261	262	264.33	264.37
		sm.	263	270	270	267.67	267.81
		bulk	257	264	278	266.33	266.19
Herta	inf.	lar.	282	273	263	272.67	272.81
		med.	264	259	239	254.00	253.62
		sm.	259	266	248	257.67	257.70
		bulk	276	269	274	273.00	273.12

Analysis of variance (as lattice exp.)

Source of variation	S.S.	D.F.	M.S.	F	5%	1%
Total	28807.95	167				
Replications	383.89	2	191.95	2.83		
Treatments	19977.95	55	363.24	5.36**	1.43	1.66
Blocks (adj.)	2434.87	21	115.95	1.71		
Error (intra-block)	6031.24	89	67.77			

Standard errors of the differences between treatment means:

Two treatments in the same block = 6.9145
Two treatments not in the same block = 7.0086
Average = 6.8848

L.S.D. $= (t_{.05})(s_{\bar{d}}) = (1.990)(6.8848) = 13.70$

$= (t_{.01})(s_{\bar{d}}) = (2.640)(6.8848) = 18.18$

Relative precision = 51.3097/47.4032 = 1.08 gain = 8%

Appendix 2. Data on number of seedlings per plot together with unadjusted and adjusted treatment means from Experiment ii, b at Lacombe in 1959

Treatments		Replications			Average	
		X	Y	Z	Unadj.	Adj.
Gateway	lar.	445	451	518	471.33	475.20
	med.	452	437	445	444.67	441.33
	sm.	393	451	467	437.00	435.39
	bulk	481	462	473	472.00	471.83
Husky	lar.	462	517	509	496.00	492.64
	med.	472	517	509	499.33	496.22
	sm.	520	526	507	517.67	520.41
	bulk	494	495	504	497.67	503.83
Parkland	lar.	486	477	501	488.00	484.76
	med.	452	492	524	489.33	489.98
	sm.	448	465	499	470.67	469.92
	bulk	481	478	468	475.67	479.13
Olli	lar.	456	457	475	462.67	464.22
	med.	430	461	493	461.33	458.84
	sm.	464	402	423	429.67	433.49
	bulk	426	423	472	440.33	440.26
Pirkka	lar.	471	449	472	464.00	464.93
	med.	369	390	409	389.33	389.66
	sm.	394	473	410	425.67	423.96
	bulk	451	436	486	457.67	458.73
Wolfe	lar.	470	515	487	490.67	493.36
	med.	505	480	539	508.00	508.66
	sm.	509	506	520	511.67	510.57
	bulk	518	521	494	511.00	511.61
O.A.C. 21	lar.	460	468	547	491.67	491.22
	med.	477	517	520	504.67	504.86
	sm.	452	511	519	494.00	496.13
	bulk	491	470	477	479.33	481.25
Nord	lar.	412	450	434	432.00	430.65
	med.	453	461	436	450.00	448.72
	sm.	494	514	486	498.00	496.07
	bulk	493	458	483	478.00	475.65
Fort	lar.	508	472	556	512.00	511.90
	med.	520	489	492	500.33	497.46
	sm.	442	458	467	455.67	453.92
	bulk	477	508	489	491.33	491.74

Appendix 3. Data on number of seedlings per plot together with unadjusted and adjusted treatment means from Experiment ii, b at Lacombe in 1960

Treatments		Replications			Average	
		X	Y	Z	Unadj.	Adj.
Gateway	lar.	492	505	540	512.33	487.74
	med.	551	563	631	581.67	577.72
	sm.	486	511	506	501.00	511.67
	bulk	477	502	527	502.00	509.63
Husky	lar.	483	441	532	485.33	457.18
	med.	584	488	542	538.00	559.55
	sm.	590	496	547	544.33	535.32
	bulk	506	538	481	508.33	491.74
Parkland	lar.	490	463	542	498.33	505.32
	med.	563	563	548	558.00	553.82
	sm.	538	540	487	521.67	500.50
	bulk	527	450	511	496.00	507.94
Olli	lar.	481	458	492	477.00	464.43
	med.	489	468	501	486.00	530.71
	sm.	461	510	568	496.33	495.92
	bulk	489	542	575	535.33	534.01
Pirkka	lar.	501	504	572	525.67	530.94
	med.	493	487	498	492.67	505.10
	sm.	340	462	508	436.67	437.70
	bulk	520	547	436	501.00	472.36
Wolfe	lar.	566	592	555	571.00	565.75
	med.	523	533	556	573.33	538.42
	sm.	468	558	562	529.33	548.26
	bulk	484	594	576	551.33	572.42
O.A.C. 21	lar.	504	536	487	509.00	503.03
	med.	535	528	559	540.67	554.19
	sm.	481	505	457	481.00	455.16
	bulk	486	543	544	524.33	503.79
Nord	lar.	454	494	551	499.67	495.93
	med.	413	503	492	469.33	453.73
	sm.	568	463	537	522.67	523.34
	bulk	456	510	538	501.33	512.29
Fort	lar.	512	532	518	520.67	546.68
	med.	502	542	588	544.00	538.73
	sm.	464	480	474	472.67	469.45
	bulk	508	533	573	538.00	559.47

Appendix 4. Results of analyses of variance on number of seedlings per plot from Experiment ii, b at Lacombe in 1959 and 1960

Source of variation	S.S.	D.F.	M.S.	F	5%	1%
Total	119703.77	107				
Replications	8564.57	2	4282.29			
Treatments (unadj.)	93339.43	35	2666.84			
Blocks (adjusted)	5782.53	15	385.50			
Error (intra-block)	12017.24	55	218.50			
Treatments (adj.)	88370.14	35	2524.86	11.56**	1.62	2.00

Standard errors of the differences between treatment means:

Two treatments in the same block = 12.4972
Two treatments not in the same block = 12.7059
Average = 12.6167

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (2.00)(12.6167) = 24.23

= $(t_{.01})(s_{\bar{d}})$ = (2.66)(12.6167) = 33.56

Relative precision = 254.28/238.77 = 1.06 gain = 6%

Source of variation	S.S.	D.F.	M.S.	F	5%	1%
Total	198009.00	107				
Replications	16108.03	2	8054.15			
Treatments (unadj.)	97463.67	35	2784.68			
Blocks (adj.)	68110.81	15	4540.72			
Error (intra-block)	16326.22	55	296.84			
Treatments (adj.)	116509.27	35	3328.84	11.21**	1.62	2.00

Standard errors of the differences between treatment means:

Two treatments in the same block = 15.1228
Two treatments not in the same block = 15.6237
Average = 15.4110

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (2.00)(15.4110) = 30.82

= $(t_{.01})(s_{\bar{d}})$ = (2.66)(15.4110) = 40.99

The relative precision = 1206.10/356.30 = 3.385 gain = 238.5%

Appendix 5. Data on number of seedlings per plot and treatment means together with the results of the analyses of variance from Experiment ii, c at Lacombe in 1959 and 1960

Treatments		a	b	c	d	Average	a	b	c	d	Average
1. Gat. L.	I	175	171	186	141	168.25	237	283	242	219	245.25
2.	II	367	347	408	351	368.25	504	426	472	444	461.50
3.	III	565	584	585	537	567.75	733	679	664	669	686.25
4. Gat. M.	I	188	180	173	139	170.00	277	257	255	232	255.25
5.	II	356	375	357	397	371.25	550	461	488	563	515.50
6.	III	533	535	601	533	550.50	863	866	866	763	839.50
7. Gat. S.	I	185	174	208	202	192.25	231	283	251	269	258.50
8.	II	411	416	401	404	408.00	477	444	455	554	482.50
9.	III	597	534	570	583	571.00	703	698	841	856	774.50
10. Husky L.	I	168	168	187	183	176.50	297	242	246	171	239.00
11.	II	356	397	357	399	377.25	475	414	442	502	458.25
12.	III	538	607	622	545	578.00	701	668	679	664	678.00
13. Husky M.	I	161	204	213	204	195.50	252	251	225	258	246.50
14.	II	346	396	354	415	377.75	496	476	573	491	496.50
15.	III	576	589	586	562	578.25	736	694	682	794	726.50
16. Husky S.	I	126	145	140	110	130.25	230	235	265	198	232.00
17.	II	398	387	382	464	407.75	482	488	499	485	488.50
18.	III	589	587	616	618	602.50	732	669	726	631	689.50
19. Wolfe L.	I	216	207	183	197	200.75	251	268	242	190	237.75
20.	II	409	399	377	436	405.25	524	458	541	478	500.25
21.	III	650	664	609	640	640.75	738	728	748	780	748.50
22. Wolfe M.	I	178	220	203	215	204.00	264	210	222	214	227.50
23.	II	447	384	411	383	406.25	502	444	544	440	482.50
24.	III	588	621	654	606	617.25	740	729	687	682	709.50
25. Wolfe S	I	200	178	194	181	188.25	231	246	246	254	244.25
26.	II	335	420	399	360	378.50	471	571	507	547	524.00
27.	III	576	620	592	638	606.50	700	807	849	736	773.00

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F	S.S.	D.F.	M.S.	F	5%
Total	3122761.67	107			4617034.33	107			
Replications	2354.85	3	784.95	1.29	5015.44	3	1671.81	1.05	2.76
Treatments	3072861.67	26	118186.99	193.89**	4488188.03	26	172622.62	108.73**	1.70
Error	47545.15	78	609.55		123830.86	78	1587.57		

L.S.D. $= (t_{.05})(s_{\bar{d}}) = (1.990)(17.456) = 34.74$

C.V. $= 2468.8/386.6 = 6.4\%$

L.S.D. $= (t_{.05})(s_{\bar{d}}) = (1.990)(28.173) = 56.06$

C.V. $= 3983.7/489.6 = 8.1\%$

Appendix 6. Data on number of seedlings per plot and treatment means together with the results of analysis of variance from Experiment ii, c at Edmonton in 1960

Treatments				a	b	c	d	Average
1.	Gat.	L.	I	214	204	225	180	205.75
2.			II	460	401	406	443	427.50
3.			III	642	641	675	587	636.25
4.	Gat.	M.	I	220	194	220	204	209.50
5.			II	472	478	428	400	444.50
6.			III	621	598	702	578	624.75
7.	Gat.	S.	I	224	182	232	206	211.00
8.			II	367	410	407	351	383.75
9.			III	579	598	584	659	605.00
10.	Husky	L.	I	198	205	185	226	153.50
11.			II	428	382	404	416	407.50
12.			III	732	617	612	670	657.75
13.	Husky	M.	I	198	219	204	208	207.25
14.			II	438	432	463	448	445.25
15.			III	469	614	636	644	640.75
16.	Husky	S.	I	205	217	196	203	205.25
17.			II	427	352	395	438	402.00
18.			III	615	555	655	705	632.50
19.	Wolfe	L.	I	213	210	226	206	213.75
20.			II	434	416	469	428	436.75
21.			III	643	621	694	662	655.00
22.	Wolfe	M.	I	216	184	207	190	199.25
23.			II	403	373	491	449	429.00
24.			III	633	686	688	645	663.00
25.	Wolfe	S.	I	202	210	203	165	195.00
26.			II	464	393	447	409	428.25
27.			III	649	604	673	683	652.25

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F	5%	1%
Total	3518913.41	107				
Replications	10947.92	3	3649.31	3.91*	2.76	4.13
Treatments	3435226.91	26	132124.11	141.68**	1.70	2.12
Error	73738.58	78	932.55			

L.S.D. $= (t_{.05})(s_{\bar{d}}) = (1.990)(21.592) = 42.97$

$= (t_{.01})(s_{\bar{d}}) = (2.638)(21.592) = 56.96$

C.V. $= 3053.7/423.1 = 7.2\%$

Appendix 7. Data on number of culms per plot and unadjusted and adjusted treatment means together with the results of analysis of variance from Experiment ii, a at Lacombe in 1959

			Replications			Average	
Treatments			X	Y	Z	Unadj.	Adj.
Park. I	non inf.	lar.	344	295	357	332.00	339.78
		med.	319	288	297	301.33	307.34
		sm.	286	274	304	288.00	280.48
		bulk	315	300	340	318.33	322.77
Park. I	inf.	lar.	320	282	321	307.67	310.11
		med.	281	274	291	282.00	290.00
		sm.	256	249	287	264.00	261.94
		bulk	299	287	263	283.00	285.43
Park. II	non inf.	lar.	353	285	350	329.33	335.03
		med.	308	291	356	318.33	322.93
		sm.	333	277	282	297.33	288.72
		bulk	322	300	263	295.00	300.15
Park. II	inf.	lar.	294	290	341	308.33	316.38
		med.	283	272	269	274.67	281.00
		sm.	272	252	300	274.67	270.30
		bulk	328	298	306	310.67	309.19
Mont.	non inf.	lar.	390	348	357	365.00	361.74
		med.	319	335	306	320.00	329.76
		sm.	249	281	286	272.00	274.41
		bulk	352	294	333	326.33	319.92
Mont.	inf.	lar.	355	356	303	338.00	347.32
		med.	323	282	360	321.67	324.75
		sm.	306	283	277	288.67	285.33
		bulk	293	296	307	298.67	296.60
Gate.	non inf.	bulk	482	468	481	477.00	458.04
		med.	423	419	446	429.33	420.25
		sm.	342	300	326	322.67	329.05
		bulk	416	401	492	436.33	437.66
Gate.	inf.	lar.	404	386	426	405.33	402.87
		med.	286	274	304	288.00	280.48
		sm.	310	311	366	329.00	329.44
		bulk	347	403	356	368.67	364.86
Wolfe	non inf.	lar.	408	373	427	402.67	404.62
		med.	342	312	372	342.00	345.81
		sm.	341	281	343	321.67	313.19
		bulk	357	359	355	357.00	357.93
Wolfe	inf.	lar.	351	375	358	361.33	355.66
		med.	340	327	400	355.67	349.53
		sm.	304	292	291	295.67	290.65
		bulk	362	306	328	332.00	337.51

Appendix 7. (continued)

Treatments			Replications			Average	
			X	Y	Z	Unadj.	Adj.
Comp.	non inf.	lar.	747	641	698	695.33	705.46
		med.	644	647	676	655.67	668.65
		sm.	594	554	643	597.00	585.96
		bulk	649	701	665	671.67	656.44
Comp.	inf.	lar.	794	649	681	708.00	712.63
		med.	675	665	702	680.67	686.03
		sm.	503	620	617	580.00	577.87
		bulk	665	617	667	649.67	651.41
Herta	non inf.	lar.	586	500	469	518.33	514.01
		med.	486	430	547	487.67	489.19
		sm.	435	421	435	430.33	430.42
		bulk	531	419	457	469.00	463.09
Herta	inf.	lar.	547	544	597	562.67	563.64
		med.	533	504	549	528.67	529.13
		sm.	478	470	514	487.33	485.87
		bulk	554	620	651	608.33	601.97

Analysis of variance (as lattice exp.)

Source of variation	S.S.	D.F.	M.S.	F	5%	1%
Total	2925301.91	167				
Replications	22259.81	2	11129.91	17.58		
Treatments	2810753.24	55	51104.60	80.75**	1.43	1.66
Blocks (adj.)	35965.09	21	1712.62			
Error (intra-block)	56323.77	89	632.85			

Standard errors of the differences between treatment means:

Two treatments in the same block = 21.4686
Two treatments not in the same block = 21.9203
Average = 21.5963

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(21.5963) = 42.98

$(t_{.01})(s_{\bar{d}})$ = (2.640)(21.5963) = 57.01

Relative precision = 559.33/466.45 = 1.20 gain = 20%

Appendix 8. Data on number of culms per plot together with unadjusted and adjusted treatment means from Experiment ii, b at Lacombe in 1959

Treatments		Replications			Average	
		X	Y	Z	Unadj.	Adj.
Gateway	lar.	1071	830	808	903.00	894.74
	med.	934	755	716	801.67	796.35
	sm.	800	713	767	760.00	773.34
	bulk	884	845	700	809.67	824.85
Husky	lar.	794	651	646	697.00	694.56
	med.	773	616	573	654.00	652.73
	sm.	787	646	569	667.33	671.45
	bulk	764	636	592	664.00	666.10
Parkland	lar.	679	565	554	599.33	610.24
	med.	668	581	556	601.67	584.49
	sm.	657	538	540	578.33	576.31
	bulk	679	541	530	583.33	581.20
Olli	lar.	822	660	635	705.67	699.12
	med.	567	625	670	620.66	624.49
	sm.	601	609	534	581.33	585.03
	bulk	521	636	638	598.33	600.25
Pirkka	lar.	650	560	538	582.67	601.78
	med.	595	553	500	549.33	544.64
	sm.	563	551	511	541.67	545.70
	bulk	584	564	523	557.00	563.56
Wolfe	lar.	992	755	692	813.00	806.32
	med.	795	768	680	747.66	752.66
	sm.	844	696	663	734.33	721.29
	bulk	809	719	698	742.00	746.85
O.A.C. 21	lar.	574	579	573	575.33	582.16
	med.	585	591	599	591.67	576.02
	small	640	574	542	585.33	571.75
	bulk	656	561	556	591.00	590.84
Nord	lar.	608	585	543	578.67	583.55
	med.	616	647	500	587.67	599.80
	sm.	620	586	544	583.33	579.07
	bulk	585	628	690	634.33	639.66
Fort	lar.	626	513	545	561.33	559.31
	med.	561	530	495	528.67	536.70
	sm.	564	486	545	531.67	517.40
	bulk	581	512	493	528.67	516.34

Appendix 9. Data on number of culms per plot together with unadjusted and adjusted treatment means from Experiment ii, b at Lacombe in 1960

Treatments		Replications			Average	
		X	Y	Z	Unadj.	Adj.
Gateway	lar.	1017	960	983	986.67	941.61
	med.	779	806	831	805.33	812.54
	sm.	683	823	801	769.00	777.85
	bulk	815	764	937	838.67	887.91
Husky	lar.	716	593	717	675.33	691.52
	med.	769	685	831	761.67	774.98
	sm.	668	751	773	730.67	737.90
	bulk	790	817	737	781.33	735.76
Parkland	lar.	662	655	712	767.33	704.41
	med.	770	747	671	729.00	694.65
	sm.	703	600	608	637.00	599.72
	bulk	740	615	674	676.33	675.88
Olli	lar.	844	788	804	812.00	778.36
	med.	582	682	652	638.67	693.89
	sm.	620	656	735	670.33	665.00
	bulk	602	758	769	709.66	722.71
Pirkka	lar.	690	703	760	717.67	741.60
	med.	735	629	673	679.00	650.23
	sm.	519	579	694	597.33	600.40
	bulk	747	741	556	681.33	646.43
Wolfe	lar.	949	860	806	871.67	833.34
	med.	639	746	751	712.00	707.11
	sm.	770	641	720	710.33	725.52
	bulk	650	923	789	787.33	810.67
O.A.C. 21	lar.	603	741	639	661.00	657.96
	med.	626	722	698	682.00	701.85
	sm.	652	651	636	646.33	608.56
	bulk	640	738	710	696.00	663.49
Nord	lar.	760	775	722	752.33	748.02
	med.	560	666	662	629.33	634.62
	sm.	645	664	693	667.33	684.64
	bulk	641	708	743	697.33	718.95
Fort	lar.	598	663	626	629.00	645.90
	med.	570	635	719	641.33	677.86
	sm.	571	577	589	579.00	581.04
	bulk	643	647	680	656.67	659.78

Appendix 10. Results of the analyses of variances of number of culms data from Experiment ii, b at Lacombe in 1959 and 1960

Source of variation	S.S.	D.F.	M.S.	F	5%	1%
Total	1350845.41	107				
Replications	192433.51	2	96216.76			
Treatments (Unadj.)	949149.41	35	27118.55			
Blocks (adj.)	72634.53	15	4842.30			
Error (intra-block)	136627.96	55	2484.14			
Treatments (adj.)	915329.58	35	26152.27	10.53**	1.62	2.00

Standard errors of the differences between treatment means:

Two treatments in the same block = 42.3114
Two treatments not in the same block = 43.0970
Average = 42.7614

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (2.00)(42.7614) = 85.52

= $(t_{.01})(s_{\bar{d}})$ = (2.66)(42.7614) = 113.75

Relative precision = 2989.46/2742.74 = 1.10 gain = 10%

Source of variation	S.S.	D.F.	M.S.	F	5%	1%
Total	982655.08	107				
Replications	18392.88	2	9196.44			
Treatments (unadj.)	707141.68	35	20204.05			
Blocks (adj.)	187257.97	15	12483.87			
Error (intra-block)	69862.55	55	1270.23			
Treatments (adj.)	583130.76	35	16660.88	13.12**	1.62	2.00

Standard errors of the differences between treatment means:

Two treatments in the same block = 31.1978
Two treatments not in the same block = 32.1870
Average = 31.7648

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (2.00)(31.7648) = 63.53

$(t_{.01})(s_{\bar{d}})$ = (2.66)(31.7648) = 84.49

Relative precision = Error M.S./Eff. error M.S. = 3673.15/1514.49 = 2.42

gain = 142%

Appendix 11. Data on number of culms per plot and treatment means together with rhe results of the analyses variance from Experiment ii, c at Lacombe in 1959 and 1960

Treatments		a	b	c	d	Average	a	b	c	d	Average
1. Gat. L.	I	593	545	582	463	545.75	570	588	583	559	575.00
2.	II	772	700	836	686	748.50	775	728	717	716	734.00
3.	III	897	754	803	762	804.00	901	855	859	801	854.00
4. Gat. M.	I	582	502	478	470	508.00	508	511	495	575	522.25
5.	II	695	613	703	728	684.75	711	626	672	776	696.25
6.	III	844	795	884	728	812.75	941	957	935	854	921.75
7. Gat. S.	I	603	477	485	544	527.25	491	483	495	544	503.25
8.	II	760	640	775	671	711.50	680	703	715	747	711.25
9.	III	868	717	802	786	793.25	829	749	844	855	826.75
10. Husky L.	I	470	462	504	469	476.25	621	536	528	444	532.25
11.	II	640	609	582	569	600.00	717	640	599	731	671.75
12.	III	700	670	688	561	654.75	799	774	768	726	766.75
13. Husky M.	I	456	505	509	497	491.75	567	508	488	607	542.50
14.	II	581	494	559	530	541.00	689	618	730	678	678.75
15.	III	662	640	626	610	634.50	792	719	735	847	783.25
16. Husky S.	I	344	391	369	331	358.75	491	375	507	428	450.25
17.	II	571	531	501	529	533.00	699	662	543	517	605.25
18.	III	656	623	669	652	650.00	768	727	758	673	731.50
19. Wolfe L.	I	647	567	516	605	583.75	481	538	495	557	517.75
20.	II	776	673	714	650	703.25	639	660	677	773	687.25
21.	III	754	750	705	614	705.75	773	752	792	802	779.75
22. Wolfe M.	I	557	560	517	516	537.50	450	423	406	428	426.75
23.	II	783	623	556	636	649.50	608	534	631	604	594.25
24.	III	736	678	683	651	687.00	780	752	720	714	741.50
25. Wolfe S.	I	537	463	458	425	470.75	428	370	394	520	428.00
26.	II	667	560	596	538	590.25	562	658	576	666	615.50
27.	III	728	664	661	677	682.50	719	826	889	831	816.25

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F	S.S.	D.F.	M.S.	F	5%
Total	1547958.00	107			2134934.55	107			
Replications	84452.50	3	28150.83	16.89**	12863.65	3	4287.88	1.75	2.76
Treatments	1333497.50	26	51288.37	30.77**	1935750.25	26	74451.93	31.17**	1.70
Error	130008.00	78	1666.77		186320.65	78	2388.73		

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(28.87) = 57.45

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(34.56) = 68.77

C.V. = 4081.7/618.0 = 6.6%

C.V. = 4887.6/656.1 = 7.4%

Appendix 12. Data on number of culms per plot and treatment means together with the results of the analyses of variance from Experiment ii, c at Edmonton in 1959 and 1960

Treatments		a	b	c	d	Average	a	b	c	d	Average
1. Gat. L.	I	796	871	551	559	695.25	864	827	716	577	746.00
2.	II	1064	988	902	932	971.50	1221	1169	947	1132	1117.25
3.	III	1361	1193	1041	1028	1055.75	1455	1468	1135	1155	1303.25
4. Gat. M.	I	808	666	585	626	671.25	870	732	583	632	704.25
5.	II	1169	936	993	949	1011.75	1242	1269	872	951	1083.50
6.	III	1055	1209	1070	1114	1112.00	1488	1554	1121	1131	1323.50
7. Gat. S.	I	711	555	539	595	600.00	831	754	584	612	695.25
8.	II	1021	768	789	964	885.50	1052	1127	954	801	983.50
9.	III	1142	978	927	1063	1027.50	1420	1364	1179	1208	1292.75
10. Husky L.	I	764	670	635	733	700.50	777	873	625	751	756.50
11.	II	878	900	858	889	881.25	1130	1071	836	993	1007.50
12.	III	1149	1216	1012	982	1089.75	1167	1145	1041	917	1067.50
13. Husky M.	I	721	506	497	618	585.50	734	940	651	685	752.50
14.	II	980	828	698	899	851.25	1013	1083	954	911	990.25
15.	III	1079	936	862	942	954.75	1123	1255	972	1018	1092.00
16. Husky S.	I	694	504	380	394	493.00	723	928	528	585	691.00
17.	II	955	862	765	857	859.75	1047	961	793	874	918.75
18.	III	950	1229	860	962	1000.25	1065	1097	980	1040	1045.50
19. Wolfe L.	I	706	646	571	679	650.50	885	961	651	696	798.25
20.	II	875	921	780	860	859.00	1161	1156	990	959	1066.50
21.	III	1208	929	905	834	969.00	995	1168	851	1033	1011.75
22. Wolfe M.	I	725	708	452	628	628.25	811	776	603	533	680.75
23.	II	1110	961	981	825	969.25	1026	1044	835	930	958.75
24.	III	1079	901	784	780	886.00	1070	1159	740	1046	1003.75
25. Wolfe S.	I	702	466	507	579	563.50	634	765	488	428	578.75
26.	II	1030	831	609	799	817.25	1193	965	757	687	900.50
27.	III	1177	935	790	954	964.00	1104	1109	793	829	958.75

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F	S.S.	D.F.	M.S.	F	5%
Total	4615071.5	107			5856355.1	107			
Replications	605974.6	3	201991.53	32.46**	1253792.2	3	417597.40	76.21**	2.76
Treatments	3523670.7	26	135525.80	21.78**	4175172.6	26	160583.56	29.31**	1.70
Error	485426.2	78	6223.41		427390.3	78	5479.36		

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(55.78) = 111.00

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(52.34) = 104.16

C.V. = 7888.6/846.4 = 9.3%

C.V. = 7402.3/945.5 = 7.8%

Appendix 13. Transformed data on number of smutted heads per plot and treatment means, together with the results of analysis of variance from Experiment ii, a at Lacombe in 1959

Treatments				Replications X	Y	Z	Average
Park. I	non	inf.	lar.	1.170	0.710	1.029	0.970
			med.	1.987	1.903	1.587	1.826
			sm.	2.086	1.400	1.463	1.650
			bulk	1.204	1.353	1.503	1.353
Park. I		inf.	lar.	1.323	1.100	0.900	1.108
			med.	1.100	1.400	1.091	1.197
			sm.	1.435	1.452	1.497	1.461
			bulk	1.356	1.375	1.421	1.384
Park. II	non	inf.	lar.	1.034	0.710	1.166	0.970
			med.	1.565	1.489	1.741	1.598
			sm.	1.414	2.027	1.827	1.756
			bulk	1.319	1.353	1.549	1.407
Park. II		inf.	lar.	1.594	0.916	1.403	1.304
			med.	1.507	1.403	1.761	1.567
			sm.	1.752	1.697	1.682	1.710
			bulk	1.315	1.688	1.345	1.449
Mont.	non	inf.	lar.	0.710	0.710	0.883	0.768
			med.	0.900	0.710	0.911	0.840
			sm.	1.304	0.710	0.922	0.979
			bulk	0.710	0.710	0.710	0.710
Mont.		inf.	lar.	1.029	1.157	1.077	1.088
			med.	1.319	1.386	1.375	1.360
			sm.	1.670	2.256	2.278	2.069
			bulk	1.594	1.479	1.763	1.612
Gate.	non	inf.	lar.	0.954	0.964	1.153	1.024
			med.	1.828	1.628	2.022	1.826
			sm.	1.849	2.971	2.189	2.336
			bulk	2.027	1.655	1.772	1.818
Gate.		inf.	lar.	1.723	1.253	1.200	1.392
			med.	2.200	1.884	2.124	2.069
			sm.	1.068	1.453	1.367	1.296
			bulk	1.587	1.578	1.378	1.514
Wolfe	non	inf.	lar.	0.710	0.710	0.710	0.710
			med.	0.889	0.710	0.710	0.770
			sm.	0.710	0.710	0.710	0.710
			bulk	0.710	0.710	0.883	0.769
Wolfe		inf.	lar.	0.710	1.140	0.710	0.853
			med.	1.931	1.192	1.414	1.512
			sm.	1.571	1.597	1.703	1.624
			bulk	1.153	1.345	0.894	1.131

Treatments			Replications X	Y	Z	Average
Comp.	non inf.	lar.	0.710	0.812	0.710	0.744
		med.	0.710	0.710	0.710	0.710
		sm.	0.710	0.710	0.710	0.710
		bulk	0.710	0.710	0.806	0.742
Comp.	inf.	lar.	1.277	0.900	1.109	1.095
		med.	0.969	1.360	1.034	1.121
		sm.	1.513	1.709	1.400	1.541
		bulk	1.467	1.145	0.894	1.169
Herta	non inf.	lar.	0.710	0.710	0.710	0.710
		med.	0.710	0.710	0.710	0.710
		sm.	0.710	0.710	0.710	0.710
		bulk	1.020	0.710	0.710	0.813
Herta	inf.	lar.	0.710	0.933	0.710	0.784
		med.	0.710	0.710	0.825	0.748
		sm.	0.959	0.710	0.710	0.793
		bulk	1.020	0.710	0.710	0.813

Analysis of variance

Source of variation	S.S.	D.F.	M.S.	F	5%	1%
Total	34.990	167				
Replications	0.039	2	0.0195	<1		
Treatments	30.716	55	0.5585	14.51**	1.43	1.66
Error	4.235	110	0.0385			

Standard error of the difference between treatment means = $s_{\bar{d}} = \sqrt{2s^2/r}$

$= 0.1602$

L.S.D. $= (t_{.05})(s_{\bar{d}}) = (1.980)(0.1602) = 0.3172$

$= (t_{.01})(s_{\bar{d}}) = (2.617)(0.1602) = 0.4192$

Appendix 14. Transformed data on number of smutted heads per plot and treatment means from Experiment ii, b at Lacombe in 1959

Treatments		Replications X	Y	Z	Average
Gateway	lar.	0.710	1.158	1.170	1.013
	med.	1.334	1.196	1.852	1.461
	sm.	1.118	1.895	1.536	1.516
	bulk	0.916	1.694	1.536	1.382
Husky	lar.	0.710	0.710	0.710	0.710
	med.	0.710	1.145	0.922	0.925
	sm.	1.591	1.432	1.315	1.446
	bulk	1.136	1.200	1.229	1.188
Parkland	lar.	1.113	1.100	1.104	1.106
	med.	1.183	1.432	1.456	1.357
	sm.	1.122	1.473	1.473	1.356
	bulk	1.732	1.533	1.418	1.561
Olli	lar.	0.710	0.710	0.710	0.710
	med.	0.710	0.710	0.710	0.710
	sm.	0.710	0.710	0.710	0.710
	bulk	0.710	0.710	0.710	0.710
Pirkka	lar.	0.710	0.710	0.710	0.710
	med.	0.710	0.710	0.837	0.752
	sm.	0.710	0.710	0.943	0.788
	bulk	0.710	0.825	0.710	0.748
Wolfe	lar.	0.710	0.710	0.710	0.710
	med.	0.866	0.710	0.710	0.762
	sm.	0.710	0.800	0.894	0.801
	bulk	0.710	0.710	0.710	0.710
O.A.C. 21	lar.	0.710	0.710	1.010	0.810
	med.	1.162	0.710	0.911	0.928
	sm.	1.058	1.095	1.192	1.115
	bulk	0.710	1.015	0.825	0.860
Nord	lar.	0.812	0.710	0.710	0.744
	med.	0.812	0.710	0.710	0.744
	sm.	0.710	0.818	0.825	0.784
	bulk	0.710	0.710	0.889	0.770
Fort	lar.	0.812	0.943	0.825	0.860
	med.	1.179	1.493	1.145	1.272
	sm.	1.100	1.315	1.109	1.175
	bulk	1.091	0.837	1.145	1.024

Appendix 15. Tranformed data on number of smutted heads per plot and treatment means from Experiment ii, b at Lacombe in 1960

Treatments		X	Y	Z	Average
		Replications			
Gateway	lar.	0.990	0.794	0.938	0.907
	med.	1.063	0.894	1.113	1.023
	sm.	1.105	1.304	1.257	1.222
	bulk	0.894	1.187	0.943	1.008
Husky	lar.	1.010	0.954	1.237	1.067
	med.	1.703	2.152	1.114	1.656
	sm.	2.636	2.748	2.681	2.688
	bulk	1.817	1.952	1.732	1.834
Parkland	lar.	0.710	0.831	0.710	0.750
	med.	0.990	1.552	1.334	1.292
	sm.	1.311	1.389	1.187	1.296
	bulk	1.225	1.183	1.109	1.172
Olli	lar.	0.710	0.832	0.710	0.744
	med.	0.843	0.927	0.831	0.867
	sm.	0.710	0.710	0.710	0.710
	bulk	0.837	0.710	0.812	0.786
Pirkka	lar.	0.710	0.710	0.710	0.710
	med.	0.710	0.710	0.710	0.710
	sm.	0.710	1.162	1.319	1.064
	bulk	0.710	0.710	0.710	0.710
Wolfe	lar.	0.943	0.889	0.900	0.910
	med.	0.710	0.911	1.216	0.946
	sm.	1.503	1.208	1.649	1.453
	bulk	1.122	0.877	0.812	0.937
O.A.C. 21	lar.	0.837	0.710	0.831	0.793
	med.	0.710	0.710	0.710	0.710
	sm.	1.118	0.938	0.943	1.000
	bulk	0.938	0.911	0.710	0.853
Nord	lar.	0.710	0.710	0.710	0.710
	med.	0.848	0.825	0.710	0.794
	sm.	0.831	0.710	0.710	0.750
	bulk	0.938	0.710	0.818	0.822
Fort	lar.	1.149	1.300	1.136	1.195
	med.	0.710	0.710	0.710	0.710
	sm.	1.418	1.162	1.473	1.351
	bulk	1.034	1.204	1.459	1.232

Appendix 16. Results of analyses of variance on number of smutted heads per plot from Experiment ii, b at Lacombe in 1959 and 1960

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	111.815	107				
Replications	0.169	2	0.085	3.51*	3.15	4.98
Treatments	8.351	35	0.239	9.90**	1.62	2.00
Error	1.684	70	0.024			

Standard error of the differences between treatment means $= s_{\bar{d}} = \sqrt{2s^2/r}$

$= 0.1269$

L.S.D. $= (t_{.05})(s_{\bar{d}}) = (2.000)(0.1269) = 0.2538$

$= (t_{.01})(s_{\bar{d}}) = (2.660)(0.1269) = 0.3376$

Source of variation	S.S.	D.F.	M.S.	F	5%	1%
Total	18.506	107				
Replications	0.013	2	0.007	<1		
Treatments	16.826	35	0.481	20.20**	1.65	2.03
Error	1.667	70	0.024			

Standard error of the differences between treatment means $= s_{\bar{d}} = \sqrt{2s^2/r}$

$= 0.1261$

L.S.D. $= (t_{.05})(s_{\bar{d}}) = (2.000)(0.1261) = 0.2522$

$= (t_{.01})(s_{\bar{d}}) = (2.660)(0.1261) = 0.3354$

Appendix 17. Transformed data on number of smutted heads per plot and treatment means, together with the results of analyses of variance from Experiment ii, c at Lacombe in 1959 and 1960

Treatments		a	b	c	d	Average	a	b	c	d	Average
1. Gat. L.	I	0.710	0.710	1.010	1.166	0.899	0.710	0.843	0.710	1.058	0.830
2.	II	0.872	1.100	0.860	0.806	0.910	0.710	0.818	1.005	0.818	1.838
3.	III	1.029	0.877	0.933	0.872	0.928	0.800	0.889	0.800	1.192	0.920
4. Gat. M.	I	1.755	1.000	1.735	2.229	1.680	0.860	0.860	1.000	1.166	0.972
5.	II	1.442	1.280	1.622	1.913	1.564	0.818	1.044	0.913	0.905	0.925
6.	III	1.622	1.546	1.517	1.319	1.501	0.872	1.127	0.872	0.889	0.940
7. Gat. S.	I	1.729	2.166	2.546	1.806	2.062	1.118	1.233	0.710	1.086	1.037
8.	II	1.980	1.435	1.755	1.783	1.738	1.183	1.015	1.010	1.221	1.107
9.	III	2.074	2.066	2.411	1.918	2.117	1.241	1.216	1.233	1.029	1.180
10. Husky L.	I	0.710	0.710	0.710	0.710	0.710	1.044	0.980	0.985	0.883	0.973
11.	II	0.710	0.710	0.710	0.922	0.763	1.005	1.208	1.058	0.818	1.022
12.	III	0.800	0.710	0.969	0.710	0.797	1.192	0.905	1.334	1.233	1.166
13. Husky M.	I	1.261	1.136	1.568	0.710	1.169	1.761	1.480	1.942	1.054	1.559
14.	II	1.432	1.145	1.179	1.118	1.218	2.017	2.117	1.741	1.691	1.891
15.	III	1.364	1.063	1.393	0.995	1.204	0.837	1.456	1.735	1.396	1.356
16. Husky S.	I	1.288	1.233	1.364	1.187	1.268	2.400	2.893	3.118	2.126	2.634
17.	II	1.442	1.661	2.119	1.606	1.707	2.581	2.502	2.617	2.396	2.524
18.	III	1.253	1.884	1.411	1.806	1.589	2.748	2.665	2.851	2.739	2.750
19. Wolfe L.	I	0.710	0.710	0.710	1.000	0.783	0.710	1.192	1.000	1.077	0.995
20.	II	0.710	0.710	0.710	0.710	0.710	1.208	0.933	0.710	0.710	0.890
21.	III	0.710	0.710	0.710	0.710	0.710	0.812	1.149	1.131	1.127	1.055
22. Wolfe M.	I	0.710	0.710	0.854	1.039	0.828	1.149	1.039	1.308	0.710	1.052
23.	II	0.710	0.806	0.710	0.710	0.759	1.229	0.980	1.131	0.954	1.074
24.	III	0.710	0.710	0.710	0.979	0.777	1.063	1.149	0.818	1.371	1.100
25. Wolfe S.	I	0.710	0.710	0.969	0.710	0.775	1.284	1.578	1.435	0.985	1.321
26.	II	0.806	1.019	0.917	1.025	0.692	1.261	0.831	0.964	1.591	1.162
27.	III	1.208	0.806	0.806	0.894	0.929	1.166	0.949	1.323	1.459	1.224

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F	S.S.	D.F.	M.S.	F	5%	1%
Total	23.581	107			34.172	107				
Replications	0.242	3	0.081	1.89	0.090	3	0.030	<1	2.76	4.13
Treatments	20.007	26	0.770	18.02**	30.275	26	1.164	23.76**	1.70	2.12
Error	3.332	78	0.043		3.807	78	0.049			

L.S.D. $= (t_{.05})(s_{\bar{d}}) = (1.990)(0.1483) = 0.295$ L.S.D. $= (t_{.05})(s_{\bar{d}}) = (1.990)(0.1581) = 0.315$

C.V. = 20.74/1.15 = 18.0% C.V. = 22.14/1.28 = 17.3%

Appendix 18. Transformed data on number of smutted heads per plot and treatment means, together with the results of the analysis of variance from Experiment ii, c at Edmonton in 1960

Treatments				a	b	c	d	Average
1.	Gat.	L.	I	0.979	0.860	0.959	0.818	0.904
2.			II	0.710	0.818	0.959	0.765	0.813
3.			III	0.877	1.053	0.872	0.765	0.892
4.	Gat.	M.	I	1.095	0.877	0.818	0.905	0.924
5.			II	1.104	0.943	0.781	0.959	0.947
6.			III	1.020	0.905	0.825	0.765	0.879
7.	Gat.	S.	I	1.257	1.196	0.818	1.072	1.086
8.			II	1.581	1.179	0.959	1.412	1.283
9.			III	0.995	1.005	1.233	1.187	1.105
10.	Husky	L.	I	0.710	0.979	0.812	1.082	0.896
11.			II	0.825	0.710	0.927	0.894	0.839
12.			III	1.091	1.010	0.938	1.216	1.064
13.	Husky	M.	I	1.794	1.622	1.425	1.345	1.547
14.			II	1.729	1.729	1.706	1.432	1.649
15.			III	1.805	1.029	0.872	1.439	1.286
16.	Husky	S.	I	2.090	1.631	2.561	2.546	2.207
17.			II	2.211	2.596	2.433	2.516	2.439
18.			III	2.437	2.229	2.532	2.598	2.449
19.	Wolfe	L.	I	0.710	0.710	0.979	0.710	0.777
20.			II	0.916	0.964	0.710	1.063	0.913
21.			III	1.000	0.964	0.985	1.086	1.009
22.	Wolfe	M.	I	0.710	0.943	1.221	1.200	1.019
23.			II	0.889	1.245	0.787	0.905	0.957
24.			III	1.029	1.049	1.086	0.831	0.999
25.	Wolfe	S.	I	1.265	1.609	1.530	0.710	1.279
26.			II	1.265	1.153	1.192	1.682	1.323
27.			III	1.236	1.145	1.229	1.439	1.277

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F	5%	1%
Total	26.354	107				
Replications	0.054	3	0.018	<1		
Treatments	22.949	26	0.883	20.53**	1.70	2.12
Error	3.351	78	0.043			

L.S.D. $= (t_{.05})(s_{\bar{d}}) = (1.990)(0.1483) = 0.295$

$= (t_{.01})(s_{\bar{d}}) = (2.638)(0.1483) = 0.391$

C.V. $= 20.74/1.21 = 17.1\%$

Appendix 19. Data in grams on 1000-kernel weight per plot and unadjusted, adjusted treatment means, together with the results of analysis of variance from Experiment ii, a at Lacombe in 1959

Treatments			Replications			Average	
			X	Y	Z	Unadj.	Adj.
Park. I	non inf.	lar.	38.60	36.52	36.40	37.17	37.13
		med.	36.78	36.60	36.55	36.64	36.91
		sm.	36.98	35.40	37.42	36.60	36.39
		bulk	37.75	35.45	36.52	36.57	36.75
Park. I	inf.	lar.	37.50	37.00	37.45	37.31	37.45
		med.	38.28	35.97	37.70	37.32	37.72
		sm.	36.28	36.00	37.50	36.59	36.63
		bulk	37.55	36.85	35.85	36.75	36.93
Park. II	non inf.	lar.	38.10	38.55	35.10	37.07	37.14
		med.	37.15	37.87	37.52	37.51	37.41
		sm.	37.98	35.90	35.65	36.51	36.59
		bulk	38.17	37.27	35.62	37.02	37.10
Park. II	inf.	lar.	38.50	36.70	36.10	37.10	37.28
		med.	38.28	36.35	35.50	36.92	36.83
		sm.	36.15	36.22	36.92	36.43	36.66
		bulk	38.35	38.32	35.55	37.41	37.67
Mont.	non inf.	lar.	39.17	39.07	39.02	39.09	39.28
		med.	38.95	39.15	38.75	38.95	39.13
		sm.	40.50	38.42	38.52	39.15	39.26
		bulk	39.92	38.77	38.45	39.05	38.92
Mont.	inf.	lar.	39.82	39.45	38.22	39.20	39.23
		med.	41.52	39.72	39.40	40.21	39.76
		sm.	39.45	39.22	38.75	39.14	39.34
		bulk	39.30	38.85	37.92	38.69	38.72
Gate.	non inf.	lar.	31.20	31.08	31.22	31.17	30.64
		med.	31.08	31.20	29.72	30.67	30.46
		sm.	31.70	30.10	29.55	30.45	30.56
		bulk	31.12	30.60	29.92	30.55	30.57
Gate.	inf.	lar.	30.92	29.92	29.67	30.17	30.05
		med.	31.18	31.25	30.98	31.14	31.31
		sm.	32.37	30.65	30.77	31.26	31.24
		bulk	30.88	30.00	29.65	30.18	30.50
Wolfe	non inf.	lar.	35.60	36.10	36.12	35.94	36.17
		med.	36.22	35.60	35.37	35.73	35.81
		sm.	35.72	35.65	34.47	35.28	35.18
		bulk	35.35	37.10	34.17	35.54	35.37
Wolfe	inf.	lar.	36.82	36.02	35.67	36.17	36.06
		med.	35.78	35.00	34.72	35.17	35.30
		sm.	37.05	34.42	33.08	34.85	35.05
		bulk	36.67	35.52	34.97	35.72	35.76

Treatments			Replications X	Y	Z	Average Unadj.	Adj.
Comp.	non inf.	lar.	55.78	55.62	55.00	55.47	55.53
		med.	54.57	55.10	54.67	54.78	54.44
		sm.	54.25	54.17	55.27	54.56	54.34
		bulk	56.12	53.15	53.75	54.34	54.24
Comp.	inf.	lar.	56.28	54.18	51.95	54.15	53.83
		med.	50.48	53.55	51.27	51.77	51.73
		sm.	52.00	53.10	48.55	51.22	51.21
		bulk	52.47	54.65	52.20	53.11	52.95
Herta	non inf.	lar.	40.88	38.02	36.20	38.37	38.35
		med.	41.10	36.25	37.95	38.43	38.12
		sm.	39.35	38.40	37.40	38.38	38.33
		bulk	40.00	37.78	35.80	37.86	37.93
Herta	inf.	lar.	40.88	38.02	36.20	38.37	38.35
		med.	39.65	37.32	36.55	37.84	37.71
		sm.	39.70	37.90	37.85	38.48	38.47
		bulk	40.07	38.50	37.37	38.65	38.34

Analysis of variance (as lattice exp.)

Source of variation	S.S.	D.F.	M.S.	F	5%	1%
Total	7540.91	167				
Replications	60.03	2	30.02			
Treatments	7355.57	55	133.74	117.41**	1.43	1.66
Blocks (adj.)	42.30	21	2.01			
Error (intra-block)	83.01	89	0.93			

Standard error of the differences between treatment means:

Two treatments in the same block = 0.8189
Two treatments not in the same block = 0.8337
Average = 0.8289

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(0.8289) = 1.65

= $(t_{.01})(s_{\bar{d}})$ = (2.640)(0.8289) = 2.19

Relative precision = 0.759/0.687 = 1.10 gain = 10%

Appendix 20. Data on 1000-kernel weight in grams per plot, together with unadjusted and adjusted treatment means from Experiment ii, b at Lacombe in 1959

Treatments		Replications			Average	
		X	Y	Z	Unadj.	Adj.
Gateway	lar.	31.72	31.45	31.90	31.69	31.41
	med.	32.50	34.10	32.82	33.14	33.12
	sm.	33.28	35.02	33.20	33.83	33.77
	bulk	32.07	32.17	32.30	32.18	32.40
Husky	lar.	40.20	39.08	39.20	39.49	39.42
	med.	40.25	38.22	39.22	39.23	39.68
	sm.	42.07	41.72	39.95	41.25	41.14
	bulk	40.47	39.00	38.10	39.19	39.22
Parkland	lar.	38.82	37.68	38.50	38.33	38.50
	med.	38.85	38.42	37.85	38.37	38.41
	sm.	39.32	39.37	39.25	39.31	39.18
	bulk	39.70	37.50	37.45	38.22	38.26
Olli	lar.	32.28	33.15	32.65	32.69	32.48
	med.	32.62	32.37	31.82	32.27	32.47
	sm.	28.87	35.15	32.05	32.02	32.23
	bulk	32.57	33.37	34.50	33.48	33.40
Pirkka	lar.	35.62	37.97	35.85	36.48	36.54
	med.	35.47	36.42	36.32	36.07	36.10
	sm.	30.27	36.02	36.35	34.21	34.39
	bulk	34.25	35.70	35.47	35.14	35.27
Wolfe	lar.	35.52	35.67	36.10	35.76	35.42
	med.	37.14	38.00	35.92	37.02	36.92
	sm.	36.87	36.08	37.37	36.77	36.83
	bulk	35.60	38.22	36.37	36.73	36.81
O.A.C. 21	lar.	38.17	38.10	36.77	37.68	37.83
	med.	38.05	37.22	37.87	37.71	37.59
	sm.	37.80	37.02	37.17	37.33	37.05
	bulk	38.50	38.07	37.87	38.15	37.96
Nord	lar.	44.72	42.97	43.52	43.74	43.78
	med.	40.57	41.97	40.90	41.15	41.05
	sm.	42.95	41.80	41.35	42.03	41.65
	bulk	40.95	42.82	38.75	40.84	40.95
Fort	lar.	38.98	38.75	37.40	38.38	38.51
	med.	37.22	37.78	38.65	37.88	37.89
	sm.	39.75	36.90	36.55	37.74	37.75
	bulk	38.67	38.00	36.57	37.75	37.54

Appendix 21. Data on 1000-kernel weight in grams per plot, together with unadjusted and adjusted treatment means from Experiment ii, b at Lacombe in 1960

		Replications			Average	
Treatments		X	Y	Z	Unadj.	Adj.
Gateway	lar.	29.48	28.73	27.84	28.68	28.20
	med.	27.40	27.06	28.30	27.35	27.98
	sm.	30.39	28.29	29.95	29.54	30.91
	bulk	27.48	27.84	25.02	26.78	26.42
Husky	lar.	35.62	33.76	32.04	33.81	35.47
	med.	34.60	35.34	35.41	35.12	34.27
	sm.	35.64	36.95	33.63	35.41	34.55
	bulk	37.45	36.28	34.23	35.99	34.74
Parkland	lar.	35.45	34.47	32.87	34.26	35.83
	med.	35.38	35.41	36.22	35.67	35.06
	sm.	37.83	33.97	34.45	35.42	37.07
	bulk	32.62	35.34	33.26	33.74	32.61
Olli	lar.	30.60	29.57	28.65	29.61	29.24
	med.	33.36	27.21	27.68	29.42	29.01
	sm.	28.93	28.56	29.54	29.01	27.77
	bulk	28.75	27.59	29.25	28.53	28.93
Pirkka	lar.	31.47	28.05	31.06	30.19	29.84
	med.	34.66	28.73	32.58	31.99	32.32
	sm.	35.66	31.22	31.29	32.72	32.95
	bulk	33.95	30.23	27.55	30.58	31.16
Wolfe	lar.	34.63	33.72	33.96	34.10	33.97
	med.	32.49	33.34	35.92	33.92	34.28
	sm.	31.08	30.66	32.39	31.38	31.05
	bulk	32.32	35.19	34.66	34.06	33.80
O.A.C. 21	lar.	31.98	33.57	33.91	33.15	32.35
	med.	33.41	33.81	30.94	32.72	32.67
	sm.	36.52	33.62	32.48	34.21	35.13
	bulk	32.62	33.80	34.89	33.77	34.26
Nord	lar.	38.12	33.35	33.94	35.14	35.39
	med.	37.83	36.99	33.12	35.98	36.83
	sm.	34.26	35.73	32.57	34.19	34.55
	bulk	35.62	35.13	37.14	35.96	35.53
Fort	lar.	33.39	32.73	29.72	31.95	30.93
	med.	32.53	29.54	30.44	30.83	30.98
	sm.	35.72	32.44	32.75	33.64	33.02
	bulk	36.47	30.11	29.69	32.09	32.03

Appendix 22. Results of analyses of variance on 1000-kernel weight per plot from Experiment ii, b at Lacombe in 1959 and 1960

Source of variations	S.S.	D.F.	M.S.	F.	5%	1%
Total	1064.80	107				
Replications	5.23	2	2.62			
Treatments (unadj.)	965.23	35	27.58			
Blocks (adj.)	30.65	15	2.04			
Error (intra-block)	63.69	55	1.16			
Treatments (adj.)	948.73	35	27.11	23.41**	1.62	2.00

Standard errors of the differences between treatment means:

Two treatments in the same block = 0.9097
Two treatments not in the same block = 0.9249
Average = 0.9184

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (2.000)(0.9184) = 1.84

$(t_{.01})(s_{\bar{d}})$ = (2.660)(0.9184) = 2.44

Relative precision = 1.35/1.27 = 1.06 gain = 6%

Source of variations	S.S.	D.F.	M.S.	F.	5%	1%
Total	960.25	107				
Replications	50.96	2	25.48			
Treatments (unadj.)	718.03	35	20.51			
Blocks (adj.)	153.37	15	10.22			
Error (intra-block)	37.89	55	0.69			
Treatments (adj.)	716.90	35	20.48	29.68**	1.62	2.00

Standard errors of differences between treatment means:

Two treatments in the same block = 0.7290
Two treatments not in the same block = 0.7531
Average = 0.7429

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (2.000)(0.7429) = 1.49

= $(t_{.01})(s_{\bar{d}})$ = (2.660)(0.7420) = 1.98

Relative precision = 2.73/0.83 = 3.29 gain = 229%

Appendix 23. Data on 1000-kernel weight in grams per plot and treatment means, together with the results of analyses of variance from Experiment ii, c at Lacombe in 1959 and 1960

Treatments		a	b	c	d	Average	a	b	c	d	Average
1. Gate. L.	I	35.70	35.77	38.90	35.02	36.35	32.28	29.89	29.54	28.37	30.02
2.	II	32.75	33.80	31.85	32.08	32.62	29.89	28.79	26.90	26.24	27.96
3.	III	34.15	32.65	31.70	32.00	32.62	27.81	26.43	25.22	26.52	26.50
4. Gate. M.	I	35.12	36.15	34.00	35.70	35.24	31.41	30.49	29.59	29.72	30.30
5.	II	33.72	33.33	33.25	31.90	33.05	28.51	30.73	27.99	27.80	28.76
6.	III	33.62	32.70	32.00	32.15	32.62	27.94	25.85	26.64	26.25	26.87
7. Gate. S.	I	37.70	37.00	35.45	34.45	36.15	34.51	30.12	28.74	29.93	30.83
8.	II	34.20	33.82	32.77	33.98	33.69	30.51	28.59	27.18	27.37	28.41
9.	III	33.70	33.22	31.77	33.97	33.17	28.58	25.86	25.18	25.59	26.30
10. Husky L.	I	42.12	40.80	40.90	41.77	41.40	37.72	38.05	38.61	36.11	37.62
11.	II	40.35	39.97	39.85	37.10	39.32	36.99	36.10	34.74	34.63	35.62
12.	III	37.40	38.05	37.22	37.82	37.62	35.76	33.04	32.52	32.79	33.53
13. Husky M.	I	45.57	42.25	40.50	42.47	42.70	38.67	39.75	38.73	38.48	38.91
14.	II	41.70	39.50	38.15	41.92	40.32	35.54	35.74	34.20	33.99	34.87
15.	III	39.57	37.77	39.50	38.25	38.77	34.73	33.77	32.03	33.00	33.38
16. Husky S.	I	45.00	42.07	43.55	42.82	43.36	39.45	39.97	38.20	39.55	39.29
17.	II	41.75	39.82	41.72	40.08	40.84	39.95	37.52	35.42	37.63	37.63
18.	III	40.92	38.55	40.00	40.08	39.89	36.51	35.45	35.55	33.77	35.32
19. Wolfe L.	I	39.30	38.10	38.42	38.42	38.56	35.82	32.49	35.83	33.44	34.40
20.	II	37.85	36.75	35.65	36.87	36.78	33.39	33.03	30.76	33.00	32.55
21.	III	38.47	35.60	36.22	37.00	36.82	30.19	30.97	31.07	31.48	30.93
22. Wolfe M.	I	39.82	37.50	36.60	38.80	38.18	35.28	34.05	36.75	34.42	35.13
23.	II	38.05	36.52	36.70	36.90	37.04	34.51	33.79	34.52	32.72	33.89
24.	III	37.95	35.80	34.15	36.30	36.05	31.88	31.69	30.41	31.27	31.31
25. Wolfe S.	I	39.57	37.85	38.47	37.62	38.38	34.85	33.39	34.57	35.61	34.61
26.	II	38.82	37.90	37.20	36.92	37.71	35.67	34.48	32.74	34.32	34.30
27.	III	38.27	36.22	36.57	37.10	37.04	34.28	32.50	32.16	34.09	33.26

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%
Total	1079.97	107			1581.38	107			
Replications	36.62	3	12.21	13.72**	51.64	3	17.21	16.55**	2.76
Treatments	974.08	26	37.46	42.19**	1448.63	26	55.72	53.57**	1.70
Error	69.27	78	0.89		81.11	78	1.04		

L.S.D. = $(t_{.05})(s_{\bar{d}}) = (1.990)(0.671) = 1.34$

C.V. = 94.34/37.27 = 2.5%

L.S.D. = $(t_{.05})(s_{\bar{d}}) = (1.990)(0.721) = 1.43$

C.V. = 101.98/32.68 = 3.1%

Appendix 24. Data on 1000-kernel weight in grams per plot and treatment means, together with the results of analyses of variance from Experiment ii, c at Edmonton in 1959 and 1960

Treatment		a	b	c	d	Average	a	b	c	d	Average
1. Gat. L.	I	30.48	32.70	32.83	31.44	31.86	30.73	27.63	31.21	34.31	30.97
2.	II	30.88	29.31	29.80	30.28	30.07	27.78	27.32	29.87	28.77	28.44
3.	III	29.24	28.13	30.99	29.32	29.42	24.38	25.39	28.82	28.46	26.76
4. Gat. M.	I	29.72	30.57	33.02	33.47	31.57	28.41	29.46	31.79	32.59	30.56
5.	II	28.42	27.65	30.10	28.59	28.69	23.98	26.88	28.20	29.19	27.06
6.	III	27.01	27.64	29.34	28.80	28.20	25.70	23.85	29.42	27.76	26.68
7. Gat. S.	I	32.56	35.14	32.25	34.70	33.66	29.57	31.46	30.45	32.16	30.91
8.	II	28.10	29.20	28.65	29.37	28.83	25.32	26.65	28.58	29.55	27.53
9.	III	26.81	27.04	27.33	29.79	27.74	24.19	25.08	27.82	29.22	26.58
10. Husky L.	I	32.13	37.98	36.77	32.43	34.83	31.04	31.86	36.85	32.49	33.06
11.	II	29.53	31.14	32.27	30.42	30.84	23.84	25.76	30,19	30.98	27.69
12.	III	26.02	26.25	32.32	28.23	28.21	24.13	24.63	29.42	31.82	27.50
13. Husky M.	I	32.32	34.99	36.34	33.27	34.23	32.94	31.33	34.28	32.84	32.85
14.	II	28.43	27.65	33.46	32.61	30.54	25.96	26.64	30.44	30.77	28.45
15.	III	29.31	27.97	32.96	30.74	30.25	22.98	26.61	29.85	29.86	27.33
16. Husky S.	I	32.51	33.58	37.13	37.77	35.25	33.23	30.96	35.46	35.40	33.76
17.	II	29.70	31.88	34.83	32.21	32.16	28.00	28.06	33.06	32.71	30.46
18.	III	28.18	28.23	32.31	29.75	29.62	24.88	27.09	30.71	30.42	28.28
19. Wolfe L.	I	31.25	32.04	35.97	34.35	33.40	31.74	32.01	33.65	34.34	32.94
20.	II	30.24	32.54	29.87	33.78	31.61	31.42	32.36	30.68	31.86	31.58
21.	III	31.29	28.92	31.99	31.23	30.86	29.54	32.30	32.64	31.88	31.59
22. Wolfe M.	I	33.29	36.94	34.23	36.20	35.17	34.04	33.66	34.91	34.95	34.39
23.	II	32.16	32.75	32.29	31.97	32.29	27.98	30.50	29.63	32.03	30.04
24.	III	30.37	32.41	33.90	29.32	31.50	29.45	30.36	31.79	30.02	30.41
25. Wolfe S.	I	37.28	37.04	35.83	36.23	36.60	32.61	30.27	34.86	35.57	33.33
26.	II	32.58	29.48	34.02	31.89	31.99	30.24	27.42	34.45	32.79	31.23
27.	III	30.07	30.60	32.29	31.99	31.24	30.10	28.47	31.63	31.03	30.31

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%
Total	841.89	107			1023.38	107			
Replications	82.92	3	27.64	12.31**	257.86	3	85.95	45.00**	2.76
Treatments	583.81	26	22.45	9.98**	616.63	26	23.72	12.42**	1.70
Error	175.16	78	2.25		148.89	78	1.91		

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(1.061) = 2.11

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(0.977) = 1.94

C.V. = 150.00/31.50 = 4.8%

C.V. = 138.20/30.02 = 4.6%

Appendix 25. Data on yield in grams per plot and unadjusted and adjusted treatment means, together with the results of analysis of variance from Experiment ii, a at Lacombe in 1959

Treatments				Replications			Average	
				X	Y	Z	Unadj.	Adj.
Park. I	non	inf.	lar.	583	536	630	583.00	598.84
			med.	514	476	489	493.00	513.15
			sm.	417	467	544	476.00	458.03
			bulk	549	527	552	542.67	554.48
Park. I		inf.	lar.	511	500	556	522.23	530.16
			med.	436	483	480	466.33	488.99
			sm.	386	427	524	445.67	442.66
			bulk	490	540	428	486.00	501.18
Park. II	non	inf.	lar.	597	517	565	559.67	563.20
			med.	492	553	632	559.00	560.36
			sm.	543	431	447	473.67	464.58
			bulk	543	522	407	490.67	501.33
Park. II		inf.	lar.	480	497	525	500.67	517.95
			med.	454	474	467	465.00	488.58
			sm.	439	388	506	444.33	434.12
			bulk	549	539	494	527.33	533.87
Mont.	non	inf.	lar.	559	548	524	543.67	546.87
			med.	424	514	417	451.67	475.03
			sm.	391	351	329	357.00	365.22
			bulk	452	401	412	421.67	407.71
Mont.		inf.	lar.	507	522	397	475.33	487.58
			med.	441	409	523	457.67	448.73
			sm.	335	337	304	325.33	320.87
			bulk	373	399	357	376.33	371.54
Gate.	non	inf.	lar.	546	512	536	531.33	484.79
			med.	406	486	445	445.67	424.81
			sm.	347	290	299	312.00	328.84
			bulk	410	417	501	442.67	435.92
Gate.		inf.	lar.	416	397	446	417.67	411.70
			med.	419	379	370	389.33	399.44
			sm.	321	324	389	344.67	343.23
			bulk	351	417	356	374.67	376.13
Wolfe	non	inf.	lar.	612	610	656	626.00	629.01
			med.	580	520	605	568.33	577.92
			sm.	533	418	517	489.33	469.51
			bulk	553	617	490	553.33	552.97
Wolfe		inf.	lar.	604	639	610	617.67	607.63
			med.	545	519	584	549.33	538.78
			sm.	490	455	412	452.33	450.90
			bulk	602	496	504	534.00	549.69

Appendix 25. (continued)

Treatments			Replications X	Y	Z	Average Unadj.	Adj.
Comp.	non inf.	lar.	551	476	533	520.00	543.79
		med.	442	476	491	469.67	489.37
		sm.	440	410	474	441.33	411.74
		bulk	437	468	476	460.33	432.15
Comp.	inf.	lar.	574	449	399	474.00	477.90
		med.	380	387	437	401.33	408.32
		sm.	287	414	299	333.33	332.12
		bulk	360	392	412	388.00	389.41
Herta	non inf.	lar.	345	270	292	302.33	365.22
		med.	363	292	413	356.00	347.12
		sm.	276	321	313	303.33	305.98
		bulk	352	297	288	312.33	305.83
Herta	inf.	lar.	415	399	419	411.00	407.67
		med.	384	356	393	377.67	373.48
		sm.	312	330	370	337.33	338.24
		bulk	409	490	483	460.67	435.72

Analysis of variance (as lattice exp.)

Source of variation	S.S.	D.F.	M.S.	F.	5%	1%
Total	1338183.52	167				
Replications	3686.92	2	1843.46			
Treatments	1126220.12	55	20476.73	19.11**	1.43	1.66
Blocks (adj.)	112903.19	21	5376.34			
Error (intra-block)	95373.29	89	1071.61			

Standard errors of the differences between treatment means:

Two treatments in the same block = 28.2650
Two treatments not in the same block = 29.0045
Average = 28.7646

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(28.7646) = 57.24

$(t_{.01})(s_{\bar{d}})$ = (2.640)(28.7646) = 75.94

Relative precision = 138850.99/827.43 = 167.8 gain = 67.8%

Appendix 26. Data on yield in grams per plot, together with unadjusted and adjusted treatment means from Experiment ii, b at Lacombe in 1959

Treatments		Replications			Average	
		X	Y	Z	Unadj.	Adj.
Gateway	lar.	1087	880	970	979.00	964.81
	med.	961	916	802	893.00	896.40
	sm.	861	882	883	875.33	878.29
	bulk	969	911	779	886.33	897.52
Husky	lar.	1164	1110	1144	1139.33	1146.05
	med.	1070	1092	1113	1091.67	1093.71
	sm.	1115	1180	972	1089.00	1100.05
	bulk	1119	1078	1110	1102.33	1110.21
Parkland	lar.	1180	960	1010	1050.00	1053.15
	med.	1064	975	1013	1017.33	1015.48
	sm.	1074	1010	1028	1037.33	1034.43
	bulk	1104	915	900	973.00	973.81
Olli	lar.	905	863	845	871.00	864.48
	med.	892	820	855	855.67	857.24
	sm.	860	860	745	921.67	826.41
	bulk	820	879	868	855.67	850.25
Pirkka	lar.	1057	1024	898	993.00	1000.55
	med.	918	945	878	913.67	920.37
	sm.	895	936	832	887.67	892.83
	bulk	1010	977	900	962.33	960.65
Wolfe	lar.	1350	1208	1102	1220.00	1212.10
	med.	1297	1229	1120	1215.33	1219.03
	sm.	1257	1110	1100	1155.67	1154.82
	bulk	1158	1153	1127	1146.00	1144.16
O.A.C. 21	lar.	891	982	916	929.67	931.83
	med.	819	899	943	887.00	887.12
	sm.	866	799	761	808.67	796.01
	bulk	916	907	855	892.67	901.94
Nord	lar.	1042	970	902	971.33	963.76
	med.	896	940	878	904.67	903.70
	sm.	875	910	859	881.33	884.91
	bulk	953	954	870	925.67	925.02
Fort	lar.	925	695	768	796.00	789.92
	med.	790	648	799	745.67	745.27
	sm.	821	739	673	744.33	737.01
	bulk	819	768	704	763.67	748.70

Appendix 27. Data on yield in grams per plot, together with unadjusted and adjusted treatment means from Experiment II, b at Lacombe in 1960

Treatments		Replications			Average	
		X	Y	Z	Unadj.	Adj.
Gateway	lar.	844	816	789	816.33	768.52
	med.	577	559	790	642.00	656.63
	sm.	527	535	714	592.00	643.36
	bulk	674	517	702	631.00	654.48
Husky	lar.	889	768	804	820.33	884.09
	med.	822	802	779	801.00	779.44
	sm.	680	784	691	718.33	686.02
	bulk	767	840	794	800.33	735.42
Parkland	lar.	685	795	785	755.00	825.11
	med.	726	635	704	688.33	663.80
	sm.	808	663	612	694.33	739.20
	bulk	753	653	588	664.67	618.82
Olli	lar.	725	732	620	692.33	665.04
	med.	445	428	554	475.67	482.76
	sm.	492	528	650	556.67	532.65
	bulk	531	613	643	595.67	638.10
Pirkka	lar.	731	552	678	653.67	662.70
	med.	790	507	643	646.67	635.49
	sm.	634	555	627	605.33	614.14
	bulk	845	779	432	685.33	687.03
Wolfe	lar.	1098	880	846	941.33	895.89
	med.	731	656	744	710.33	726.97
	sm.	686	577	540	601.00	597.30
	bulk	705	866	651	740.67	736.34
O.A.C. 21	lar.	684	772	620	692.00	657.35
	med.	648	589	544	593.67	603.90
	sm.	708	528	505	580.33	598.13
	bulk	687	696	703	695.33	677.18
Nord	lar.	762	498	497	585.67	605.83
	med.	482	695	484	553.67	581.85
	sm.	535	560	483	526.00	545.07
	bulk	465	486	698	549.67	543.18
Fort	lar.	581	708	569	619.33	586.17
	med.	588	530	563	560.33	593.27
	sm.	690	525	526	580.33	553.95
	bulk	636	547	584	589.00	578.50

Appendix 28. Results of analyses of variance on yield per plot from Experiment ii, b at Lacombe in 1959 and 1960

Source of variations	S.S.	D.F.	M.S.	F.	5%	1%
Total	2095909.70	107				
Replications	116080.20	2	58040.10			
Treatments (unadj.)	1753035.00	35	50086.71			
Blocks (adj.)	68466.84	15	4564.46			
Error (intra-block)	158327.66	55	2878.68			
Treatments (adj.)	1733439.09	35	49526.83	17.20**	1.62	2.00

Standard errors of the differences between treatment means:

Two treatments in the same block = 45.1330
Two treatments not in the same block = 45.7810
Average = 45.5033

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (2.000)(45.5033) = 91.01

$(t_{.01})(s_{\bar{d}})$ = (2.660)(45.5033) = 121.04

Relative precision = 3239.92/3105.81 = 1.04 gain = 4%

Source of variations	S.S.	D.F.	M.S.	F.	5%	1%
Total	1620700.77	107				
Replications	39803.67	2	19901.84			
Treatments (unadj.)	979752.77	35	27992.94			
Blocks (adj.)	349048.41	15	23269.89			
Error (intra-block)	252095.92	55	4583.56			
Treatments (adj.)	829233.11	35	23120.95	5.04**	1.62	2.00

Standard errors of the differences between treatment means:

Two treatments in the same block = 58.560
Two treatments not in the same block = 60.572
Average = 59.845

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (2.000)(59.845) = 119.69

$(t_{.01})(s_{\bar{d}})$ = (2.660)(59.845) = 159.19

Relative precision = 8587.76/5371.94 = 1.59 gain = 59%

Appendix 29. Data on yield in grams per plot and treatment means, together with the results of the analyses of variance from Experiment ii, c at Lacombe in 1959 and 1960

Treatments		a	b	c	d	Average	a	b	c	d	Average
Gate. L	I	880	817	831	678	801.50	635	587	616	536	593.50
	II	890	860	915	750	853.75	672	577	546	667	615.50
	III	1007	821	869	857	888.50	902	624	586	701	703.25
Gate. M.	I	800	709	602	683	698.50	538	503	410	563	503.50
	II	787	826	832	828	818.25	621	554	486	640	575.25
	III	981	913	947	837	919.50	635	603	591	652	620.25
Gate. S.	I	914	675	659	726	743.50	507	472	433	513	481.25
	II	883	838	856	810	846.75	504	551	576	586	554.25
	III	883	751	735	892	815.25	592	550	540	568	562.50
Husky L.	I	894	918	1043	927	945.50	836	818	813	560	756.75
	II	1148	1086	918	1016	1042.00	951	816	680	813	815.00
	III	1201	1191	1165	1072	1157.25	991	870	834	706	850.25
Husky M.	I	951	1099	1047	1042	1034.75	748	806	648	767	742.25
	II	1054	1004	992	1018	1017.00	817	759	791	694	765.25
	III	1028	1119	1084	1130	1090.25	879	742	794	804	804.75
Husky S.	I	709	868	822	746	786.25	704	499	653	504	590.00
	II	1020	1017	985	1030	1013.00	762	806	699	589	714.00
	III	1187	1036	1220	1187	1157.50	810	783	786	732	777.75
Wolfe L.	I	1028	1008	874	1038	987.00	615	627	559	671	618.00
	II	1248	1082	1085	1122	1134.25	618	807	735	792	738.00
	III	1160	1152	1145	1077	1133.50	873	712	736	805	781.50
Wolfe M.	I	890	982	876	877	906.25	544	605	533	528	552.50
	II	1194	993	952	1026	1041.25	730	640	594	676	660.00
	III	1212	1145	1054	1130	1135.25	815	715	674	711	728.75
Wolfe S.	I	892	842	778	757	817.25	524	430	504	547	501.25
	II	1107	958	984	960	1002.25	711	627	528	492	589.50
	III	1174	1002	1115	1157	1112.00	768	721	653	695	709.25

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%
Total	3114992.3	107			1636378.7	107			
Replications	76724.6	3	25574.87	1.94	108848.3	3	36282.77	8.19**	2.76
Treatments	2010333.8	26	77320.53	5.87**	1181819.2	26	45454.58	10.26**	1.70
Error	1027933.9	78	13178.64		345711.2	78	4432.19		

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(81.175) = 161.54

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(47.075) = 93.68

C.V. = 11480.00/959.19 = 11.97%

C.V. = 6657.35/663.11 = 10.04%

Appendix 30. Data on yield in grams per plot and treatment means, together with the results of the analyses of variance from Experiment ii, c at Edmonton in 1959 and 1960

Treatments		a	b	c	d	Average	a	b	c	d	Average
Gate. L.	I	910	1055	680	750	848.75	1130	980	960	820	972.50
	II	1010	1060	935	955	990.00	1115	1155	1010	1073	1088.25
	III	1085	1105	1040	1070	1075.00	1150	1145	1138	955	1097.00
Gate. M.	I	865	765	825	920	843.75	1112	925	800	860	924.25
	II	990	890	1115	955	987.50	1100	1216	970	961	1061.75
	III	930	990	1050	1010	995.00	1118	1112	1045	937	1053.00
Gate. S.	I	925	835	710	845	828.75	1069	1018	805	820	928.00
	II	905	845	810	1094	913.50	1070	1235	1005	960	1067.50
	III	790	865	800	900	838.75	1095	890	1010	1157	1038.00
Husky L.	I	1050	1260	1290	792	1098.00	1125	1220	1180	1150	1168.75
	II	895	1205	1265	1150	1128.75	1050	1131	1182	1358	1180.25
	III	1085	980	1375	1075	1128.75	1095	1167	1410	1290	1240.50
Husky M.	I	1075	1120	910	1065	1042.50	1120	1275	1120	1090	1151.25
	II	920	990	1110	1195	1053.75	1185	1090	1260	1125	1165.00
	III	955	1175	1235	1192	1139.25	1068	1180	1270	1265	1195.75
Husky S.	I	1025	800	805	669	824.75	1070	1183	906	1043	1050.50
	II	825	1315	1265	1210	1153.75	1173	1029	1103	1155	1115.00
	III	895	965	1250	1190	1075.00	945	1125	1230	1178	1119.50
Wolfe L.	I	850	865	1005	1170	972.50	1188	1282	1050	1055	1143.75
	II	1040	1190	985	1270	1121.25	1367	1410	1185	1330	1323.00
	III	1235	985	1220	1030	1117.50	1255	1327	1210	1160	1238.00
Wolfe M.	I	1075	1125	755	1050	1001.25	1240	1167	940	860	1051.75
	II	1120	1175	1220	1226	1185.25	1185	1205	1160	1275	1206.25
	III	1125	1175	1110	1025	1108.75	1230	1282	1105	1295	1228.00
Wolfe S.	I	1045	855	875	995	942.50	634	765	488	428	578.75
	II	1300	995	855	1115	1066.25	1193	965	757	687	900.50
	III	1290	1070	1125	1380	1216.25	1104	1109	793	829	958.75

Analysis of variance

Source of var.	S.S.	D.F.	M.S.	F.	S.S.	D.F.	M.S.	F.	5%
Total	2855014.9	107			3382323.1	107			
Replications	22267.9	3	7422.63	<1	196043.7	3	65347.90	5.39**	2.76
Treatments	1418812.9	26	54569.73	3.01**	2239682.1	26	86141.62	7.10**	1.70
Error	1413934.1	78	18127.36		946597.3	78	12135.86		

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(95.203) = 189.45

L.S.D. = $(t_{.05})(s_{\bar{d}})$ = (1.990)(77.897) = 155.02

C.V. = 13463.75/1025.81 = 13.12%

C.V. = 11016.27/1083.17 = 10.17%